'Carbon debt' – lost in the forest?

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GENERAL POSTER SESSIONS

IUFRO Division 1: Silviculture

Linking ecosystem service tradeoffs with perceived benefits from reforestation in human-modified tropical landscapes. Abelleira, O., Tavarez, H., Ramos-Bendaña, Z., Galbraith, S. (*University of Idaho, USA & CATIE, Costa Rico; ojabelleira@gmail.com; tavarez21@gmail.com; zramos@catie.ac.cr; sara.marie.galbraith@gmail.com*), Fremier, A. (*University of Idaho and Washington State University, USA; alex.fremier@wsu.edu*), Gunter, S., Elbakidze, L., Vierling, L., Bosque Pérez, N., Ordoñez, J., DeClerck, F.

Environmental policies such as payments for ecosystem services (PES) assume reforestation increases ecosystem service (ES) provisions and human welfare. In PES schemes, reforestation may include natural or plantation forests, which may result in unknown ES tradeoffs. Since ecological processes modulating ES within forests are studied at plot scale, spatial up-scaling is needed to link ES tradeoffs to economic benefits at scales perceived by residents. We aim to quantify ES tradeoffs and perceived benefits in a seasonally dry region of Costa Rica where extensive reforestation occurred partly due to PES-sponsored plantations of introduced species. We are using plot-scale measurements of water balance and pollinator diversity per forest type to calibrate spatially explicit ES modeling platforms using high resolution forest cover maps. We will examine how water yield and pollination ES link spatially to resident benefits obtained via stated-preference methods. Initial survey results showed ~30% of sampled rural residents suffer water shortages in the dry season, yet the relationship of perceived benefits with changes in forest cover and associated ES tradeoffs remain to be assessed. We expect our results will help clarify social-ecological links between ES provisions and benefits in PES and broaden the application of these methods in human-modified tropical landscapes.

Growth response of *Moringa oleifera* (Lam.) seedlings to organic and inorganic fertilizers on an Alfisol in south-western Nigeria. Adejoh, O., Shodeke, D., Yakubu, F., Igboanugo, A. (*Forestry Research Institute of Nigeria, Nigeria; bumexd@yahoo.com; shofoluwade@yahoo.com; fredyakubu@yahoo.com; aloyigboanugo@yahoo.com).*

The study investigated the effects of poultry manure (PM), spent mushroom substrate (SMS), bark of *Moringa oleifera* pod (BMP), and NPK (15:15:15) fertilizers applied singly and in combination on early growth of uniform-sized *M. oleifera* seedlings in an Alfisol in south- western Nigeria**.** The treatments were: T1=5 t/ha PM, T2=10 t/ha PM, T3=5 t/ha SMS, T4=10 t/ha SMS, T5=5 t/ha BMP, T6=10 t/ha BMP, T7=2.5 t/ha PM + 2.5 t/ha SMS, T8=2.5 t/ha PM + 2.5 t/ha BMP, T9=2.5 t/ha BMP + 2.5 t/ha SMS, T10=100 kg/ha NPK, T11=200 kg/ha NPK, and T12=control. The experiment was laid out in a completely randomized design with four replicates. Data were collected bimonthly for 6 months. The results showed that plants grown under 2.5 t/ha PM + 2.5 t/ha SMS had the highest plant height (90.6 cm) and collar diameter (8.3 mm) whereas those grown in 2.5 t/ha PM + 2.5 t/ha BMP produced significantly greater number of leaves (70.40) and branches (14.6). Thus, it is recommended that a combination of poultry manure with spent mushroom substrate should be used for raising good-sized seedlings of *M. oleifera* for plantation establishment.

Assessment of current woody species and potential candidate for forest exploitation: implication for reforestation system improvement in Benin. Akpona, A. (*Direction Générale des Forêts et des Ressources Naturelles, Benin; akpona@gmail.com*), Gogan, Y. (*Université Catholique de l'Afrique de l'Ouest, Benin; gogyan4@gmail.com*), Houessou, L., Djagoun, C., Akpona, T. (*Laboratory of Applied Ecology, Benin; houeslaur@yahoo.fr; dchabi@gmail.com; ajeandidier@gmail.com.*

Sustainable reforestation in Benin requires a forward-looking vision which predicts succession in the use of tree species for various purposes and includes it in reforestation planning. We documented current and potential candidate woody species involved in forest exploitation, the criteria which determined their choice, and the level of mastery of their production in a nursery. We surveyed 140 persons involved in tree use and performed a correspondence analysis and principal component analysis for perceived frequency citations abundance, threats, and criteria selection of species in order to establish respectively the relationship between the perceptions of abundance, threats, and the woody species as well as the criteria of choice and the woody species. A total of 31 wood species from 15 botanical families are listed as potential candidates, while 24 wood species belonging to 12 families are currently exploited for timber, art, and sculpture purposes. Thirteen criteria determined the choice of species and vary depending on the type of use. Only 40% of current woody species and potential candidates are produced in nurseries, and less than 30% of species are currently involved in reforestation programs. A long-term plan for integrating targeted species into reforestation programs is required and necessitates synergy among stakeholders.

Examining native and exotic *Pinus taeda* plantation spacing, resource availability and varietal effects using crown ideotypes. Albaugh, T., Fox, T. (*Virginia Tech, USA; tim_albaugh@vt.edu; trfox@vt.edu*), Rubilar, R. (*University of Concepción, Chile; rrubilar@ncsfnc.cfr.ncsu.edu*), Alvares, C. (*Institute of Forestry Research and Education, Brazil; clayton@ipef.com*), Stape, J. (*North Carolina State University, USA; stape@ncsfnc.cfr.ncsu.edu*).

To meet demand for forest products, from solid wood to bioenergy, managers must utilize intensive silvicultural practices including site selection, resource management, stocking, and elite genetic material including clones. While our understanding of these factors has improved tremendously in the past 50 years, questions still remain including how to evaluate clonal material and why *P. taeda* planted in the southern hemisphere typically outperforms that in the southeast United States. Our approach to address these questions has been to establish three sites (Virginia: outside native range but in the southeast United States; North Carolina: native range; and Brazil: southern hemisphere) where the same clones, mass control pollinated and open pollinated families with a range in crown ideotype, were planted at three spacings (618, 1 235, 1 853 stems/ha; from wide spacing for solid wood to narrow spacing for bioenergy biomass production), and two levels of resource availability (operational and intensive for maximum growth). We will present growth response data after 3 years to understand if crown ideotype will be useful in identifying the best silvicultural regime for a given genetic entry.

A forest for all: management for multiple uses. Axelsson, E., Strengbom, J., Lundmark, T., Nordin, A. (*Swedish University of Agricultural Sciences, Sweden; petter.axelsson@slu.se; joachim.strengbom@slu.se; Tomas.Lundmark@slu.se; Annika.Nordin@slu.se*).

Implementing multi-use management to account for both commercial and ecosystem values of managed systems is accumulating global recognition. This study explores the influence of forest management practices including thinning, nitrogen fertilization, and unmanaged control on the multi-use potential of pine (*Pinus sylvestris*) dominated forests in Sweden. The results showed that the species diversity of understory vegetation was higher in thinned than in unmanaged forests. Lichen biomass increased three-fold in thinned forests. Fertilization decreased the abundance of lingonberry shrubs (*Vaccinium vitis-idaea*) while thinning in combination with fertilization increased that of bilberry shrubs (*V. myrtillus*). Annual stem volume increment increased with fertilization but decreased with thinning. Due to these divergent effects, tradeoffs among different ecosystem services was common, e.g., thinning increased reindeer fodder potential by 200% while at the same time it decreased annual stem volume increment by 28%. We showed that forest floor vegetation responses depend both on management action and focal ecosystem delivery. Hence, it appears possible to design management actions in accordance with management goals as long as the goals are carefully specified. As tradeoffs were common and nonmonetary deliveries such as biodiversity will need consideration, a key challenge will be to decide on these goals and adjust management actions accordingly.

Introduction of adaptable tree species to arid climate in Iran: case study at Fars Province, Darab. Azhdari, F. (*University of Tehran, Iran; fatemeh_azhdari@ut.ac.ir*).

Because Iran has a dry climate, increasing forest area through plantations is of particular importance. In plantation projects, species from a known origin should be used. Lacking information on the species being planted may be hazardous to the ecosystem. Therefore, the ecological conditions of the natural distribution of the species being planted should match the area where they are being introduced. In this paper, adaptable species were introduced into Fars Province, Darab. The climatological parameters used were mean annual precipitation, mean annual temperature, maximum and minimum absolute temperature, mean relative humidity, and dry season duration. Based on the climatological indexes of De Marti and Amberge, the climate in this area was determined to be arid. Based on these studied parameters, 20 tree species were introduced for this area. Studies like this are necessary in arid area like Zagros. It is hoped that studies on management of forest parks and forestry plantations will be increased due to effective preservation and management.

Improving soil conditions to increase productivity of *Tectona grandis* in northern Costa Rica: established plantations. Briceño-Elizondo, E., Arias, D., Esquivel, E. (*Instituto Tecnologico de Costa Rica, Costa Rica; ebriceno@itcr.ac.cr; darias@itcr.ac.cr; eesquivel@itcr.ac.cr*).

Available land for Teak (*Tectona grandis*) cultivation has specific chemical and physical limitations that require further study and possible solutions. Costa Rica is required to keep reforested areas under the same use. However, as of yet no discussion on second rotation has taken place nor has there been any considerations regarding continuing with the same species or not, nutritional conditions of the site after harvesting, or what technological package will ensure a sustainable production. What is clear is that the land used to grow teak with moderate to high productivity should be maintained for timber production. This research addressed improvements to soil conditions to enhance growth by applying physical and chemical treatments not generally used in reforestation in the tropics. A three-block experimental design was established using eight treatments which included combining the effect of two deep tillage levels and three intensities of tillage implements (using 1, 3, and 5 chisel ploughs), and a fertilized no-till treatment and a control plot. The fertilization program was determined after careful soil analysis. Early treatment responses are being monitored and will help to determine what level of intensity is ideal for this species in areas of low productivity.

The Cuban experience within integrated forest farms: the case of La Aurora, Municipality of San Cristobal, Artemisa Province, Cuba. Calzadilla Zaldivar, E. (*Instituto de Investigacion Forestal, Cuba; calzadilla@forestales.co.cu*).

An integrated forest farm (IFF) is the smallest sustainable forest management unit within the system of Forest Ente. The IFFs are created in areas of forest heritage and are state owned. They constitute forests or deforested areas which are assigned to an individual known as the farm manager with a legal contract signed between the state representative and the estate manager. The objective of the estates is forestry, but as recorded by the contract, the estate manager is entitled to additional production, including the creation of subsistence crops in an area of 1.0 to 2.0 ha, as well as animal husbandry and fruit-growing, from which up to 50% of the revenues can be received by the estate manager. At the end of 2010 there were 1 367 forest estates nationwide, with the addition of 100 new farms yearly. In order to disseminate these original experiences, the IFF La Aurora was selected to represent the achievements of the program locally and nationally, and thereby to promote it to the forestry community in the Caribbean subregion.

European beech trees have developed an adaptive strategy of survival through crown die-back under stress of drought and plant competition. Chakraborty, T., Saha, S., Matzarakis, A., Reif, A. (*University of Freiburg, Germany; tamalika.chakraborty@waldbau.uni-freiburg.de; somidh.saha@waldbau.uni-freiburg.de; andreas.matzarakis@meteo.uni-freiburg.de; albert.reif@waldbau.uni-freiburg.de*).

Frequency and severity of drought will increase in central Europe. The reaction of beech trees to drought could show high plasticity at their distribution limit, especially in dry near-natural forests. Understory beech trees could have a survival strategy by developing a crown-dieback threshold. However, such hypotheses have never been tested. To test these hypotheses, five Downy oak-beech ecotones in near-natural forest stands were selected in Germany and Switzerland. Plots were installed across beech and oak dominated areas representing stand composition and moisture gradients. Crown dieback (CD) was measured as the percentage of dead aboveground biomass (AGB) to represent tree vitality. Biomass equations were formulated from the harvested trees for each stand. Soil and climatic parameters were combined to quantify drought. Crown-based spatially explicit plant competition

indices were calculated for target trees. We found that drought, competition, and slope significantly increased CD in beech trees. We calculated for the first time the survival threshold (58% of dead AGB) of beech trees at their drought limit. Irreversible damage occurred beyond this threshold and led to complete plant die-back. We concluded that plant competition along with drought was acting as a predisposing factor of beech die-back at their distribution limits.

Development and dynamics of young aspen-spruce mixedwood stands in western Canadian Boreal Forests. Comeau, P., Bokalo, M. (*University of Alberta, Canada; phil.comeau@ualberta.ca; mike.bokalo@ualberta.ca*).

The Western Boreal Growth and Yield Association (WESBOGY) is a regional association of industrial, federal, provincial, and university foresters and researchers interested in evaluating the dynamics of boreal forest development and the yield implications of silvicultural practices. The four western provinces and the Northwest Territories are represented among the members. In 1992, WESBOGY began a long-term study to evaluate the effects of aspen and spruce densities on the long-term dynamics of mixed-wood stands. Eleven replicate installations of this study have been established in western Canada since that time. This poster describes the study design and presents results from recent analyses showing height, height increment, diameter, and height/diameter ratio responses for spruce and aspen in the different treatments.

Dendroenergetic analyses of *Acacia mearnsii* De Wild. culture. Corte, A.D., Sanquetta, C., Pscheidt, H., Ruza, M., Behling, A. (*Federal University of Paraná, Brazil; anapaulacorte@gmail.com; carlos_sanquetta@hotmail.com; heloisaa_p@yahoo.com.br; marielisabrina93@gmail.com; alexandre.behling@yahoo.com.br*).

The objective of this paper was to analyze the dendroenergetic potential of *Acacia mearnsii* De Wild. (black wattle) culture throughout its growth cycle. The study was conducted on plants ranging in age from 1 to 7 years in two different locations in southern Brazil, where this species is largely cultivated. Biomass was measured by means of compartments and ages. Moreover, the superior calorific power (SCP) of samples was measured. Energetic productivity was calculated by multiplying these variables. Analyses of variance indicated there were significant differences in the assessed SCP by compartment. Leaves, bark, living branches, and wood showed a mean SCP of 5 408, 4 787, 4 692, and 4 572 Kcal/kg. The energetic productivity of biomass tended to increase in older stands, varying from 16.3 Gcal/ha for 1-year-old cultures to 635 Gcal/ha for the 7-years-old plants, with wood contributing the most to this value in all but the 1-year-old plants. To conclude, it was noticed that black wattle's energetic productivity varied according to compartment and stand age, and it has a great potential to supply further energetic demands.

Provenance trial of *Shorea leprosula* Miq. In Palembang, South Sumatra, Indonesia. Dewayani, A. (*Bogor Agricultural University, Indonesia; monica.dorothea@gmail.com*).

This research tested the growth performance of five provenances (designated A, B, C, D and E) of *Shorea leprosula* Miq. to 20 years of age in Palembang, South Sumatera, Indonesia. Parameters examined were diameter at breast height (DBH), total height, and bole height. The data from the three parameter analyzed using Analysis of Variance (Anova test) and also significant analysis with Duncan Test. Results indicated a wide genetic variance among provenances for all parameters measured parameter. Based on Anova test, provenance has a significant influence on DBH, total height, and bole height growth but no differences were apparent among blocks for these parameters. The differences among provenances indicates that there is scope for genetic improvement during the selection phase. Based on these results, the best recommended provenance is provenance E.

Teak (*Tectona grandis* Linn. f.) biomass and carbon stocks in FIO Thong Pha Phum Plantation, Western Thailand. Diloksumpun, S., Wachrinrat, C., Thongfak, C., Chumsangsri, T. (*Kasetsart University, Thailand; sapit.d@ku.ac.th; fforcrw@ku.ac.th; nitazang@hotmail.com; ffortpc@ku.ac.th*).

Forest Industry Organization (FIO) plays an important role in commercial teak (*Tectona grandis* Linn.) plantations in Thailand where significant amounts of CO_2 are stored in biomass and harvested wood products. The objective of this study was to determine the carbon storage in the Thong Pha Phum teak plantation, one of the largest FIO plantations in Thailand. The sampling plots were established in 12 stands representing the 30-year rotation. Allometric equations for biomass estimation and growth model were developed and the carbon storage was then estimated accordingly. Results indicated that all growth parameters were significantly different among stand ages ($p < 0.01$). Total biomass and carbon stored in the biomass tended to increase with age, but considerably lower biomass and carbon storage were also observed in a few stands due to the thinning schedule and/or poor site quality. In 2009, the Thong Pha Phum plantation, with a 2 213.89 ha teak plantation provided 62 019.56 Mg carbon storage, suggesting that Thong Pha Phum plantation could serve as one of the carbon sinks in Thailand where sustainable forest management is employed.

Silver fir (*Abies alba* Mill.): native or alien tree species in northern Poland. Dobrowolska, D. (*Forest Research Institute, Poland; d.dobrowolska@ibles.waw.pl*).

Silver fir is an important tree particularly in mountain forests because of its lower susceptibility to insect infestation compared to *Picea abies* Karst. The northern limit of fir distribution runs across Poland. However, fir grows outside the boarder of its range. The key objective of this study was to verify the natural distribution of the species. The main goals were: (1) to compare the structure, growth, and regeneration of silver fir inside and outside its range; and (2) to compare the vitality and damage of silver fir stands in and outside its natural range. A total of 48 plots (24 inside and 24 outside the natural range of the species) were established on two site types (fresh mixed deciduous and fresh deciduous) and in three age classes (<100 years; 101–125 years; >126 years). Data were collected on circular plots established randomly in stands containing different proportions of silver fir in the species composition. The vitality and growth of silver fir outside the limit of its natural range have been satisfactory. The results of the study will be useful for foresters and policy makers to change the approach for native and non-native species, especially under the condition of climate change.

The carbon balance in forest fuels from long rotation forestry: the outcome is in the assumptions. Egnell, G. (*Swedish University of Agricultural Sciences, Sweden; Gustaf.Egnell@slu.se*), Berndes, G. (*Chalmers University of Technology, Sweden; goran.berndes@chalmers.se*).

Many recent studies claim that biomass from long-rotation forestry for energy purposes will not contribute much to mitigating climate change. Typically these studies take a single stand approach and/or use the terminology of carbon debt, focusing on the time lag before the CO_2 immediately released when the harvested biomass is combustion is balanced by carbon captured in the subsequent stand. Other studies take a what if approach with an overexploitation of the forest resource, and few studies include the behavior of the forest owner on altering future markets for forest products or risks associated with carbon stored in forest stands. Here we present results from software developed within the Heureka project in Sweden to estimate total carbon sequestration, including soil and stand carbon, over time following different assumptions for (1) markets for forest fuels, pulpwood, and timber; (2) forest owners behavior based on market expectations; and (3) the age structure of the forest. Results are given for a single stand, a forest estate, and for the whole productive forest in Sweden based on national forest inventory data. Since the outcome is in the assumptions, they are also discussed.

Evaluation of natural regeneration of woody plants in a mixed plantation of tree species. Enciso Gomez, M., Leguizamon Aranda, A., Elias Dacosta, L. (*National University of Asuncion, Paraguay; manuelenci@yahoo.com; adanleguiaranda@gmail.com; elidaco28@gmail.com*).

The occurrence of the regeneration of woody plants in a plantation forest is important because it can eventually lead to the formation of a structure and coverage that resembles that of a natural forest. Therefore, the assessment of natural regeneration can produce results that clarify the potential to reconstitute the characteristics of a natural forest through planting. In this study we evaluated the natural regeneration in a 23-year-old mixed plantation with eight native forest species located on the campus of the National University of Asuncion, in the city of San Lorenzo, Paraguay. Sampling areas were systematically established within the plot where individuals were identified and calculations of abundance, frequency, and mixing ratio were completed. We found 20 967 individuals/ha, consisting of 13 families and 25 species. There were no regeneration individuals corresponding to the two planted species. The two species with the highest relative abundance had values of 48.01% and 14.31%, respectively. The two species with higher relative frequency at seedlings stage had values of 15.07% and 12.33%, respectively. While at pole stage, the two species with the highest relative frequency had values of 10.84% and 9.64%, respectively. The mixing ratio of species had a value of 0.04. It was concluded that the mixed planting of native forest species promotes regeneration of a large number of individuals and can be an alternative to restoring vegetation cover having the characteristics of a natural forest.

Sustainable energy from wood plantations benefits Coopetarrazú coffee. Esquivel, E., Molina Quesada, S., Arias, D., Briceño-Elizondo, E. (*Instituto Tecnológico de Costa Rica, Costa Rica; eesquivel@itcr.ac.cr; samolina117@gmail.com; darias@itcr.ac.cr; ebriceno@itcr.ac.cr*), Calvo, M. (*Coopetarrazú, Costa Rica; mcalvo@coopetarrazu.com*).

For the market value price to reflect coffee with a distinction of being produced sustainably, processing requires heat that traditionally has been obtained from burning wood. However, wood supply comes from different sources with various species, age, and heat capacities, creating differences in boilers at the industrial level, thus justifying the need to obtain a source of biomass of a standard quality for the coffee processing industry. Coopetarrazú coffee industry is located within an area where land use for coffee is inadequate and using farmsteads for forestry would be more appropriate. Using high-density plantations, we established a three-block experimental design with six treatments combining two Eucalyptus species (*Eucalyptus tereticornis* and E. *saligna*) at three stockings (5000, 10 000 and 20 000 trees/ha) in 100 m^2 plots. By periodically evaluating soil nutrients, biomass, stage of development, and carbon sequestered in soil and biomass, we have identified suitable densities and species combinations for energy production. This knowledge is of great importance to Coopetarrazú and other coffee companies.

Natural regeneration in Mediterranean pine forests: a conceptual approach under climate change. Fonseca, T.F. (*University of Trás-os-Montes e Alto Douro, Portugal; tfonseca@utad.pt*), Lucas-Borja, M. (*Universidad de Castilla La Mancha, Spain; ManuelEsteban.Lucas@uclm.es*), Rodríguez García, E., Bravo Oviedo, F. (*Universidad de Valladolid, Spain; enkaro@hotmail.com; fbravo@pvs.uva.es*).

Factors restricting natural regeneration success in Mediterranean pine forests at the earlier stages are especially complex, and some of them are not completely understood. They include year-to-year variability in seed production, post-dispersal seed predation, suitable medium for seed germination and seedling survival, diseases, and variable environmental conditions. In addition, factors can vary annually or within a given year and can vary with local conditions and season. From data obtained in *Pinus nigra* and *Pinus pinaster* stands in Spain during the last decade, results showed that the processes linked at the beginning of recruitment do not predict good expectancies in non-masting years. Moreover, seed germination, seedlings survival, and initial seedling growth are influenced by site perturbation (harvest, fire), stand density, shrub and canopy cover, and soil properties. In conclusion, the relationship between natural regeneration and all the factors involved appears to be site specific and additionally mediated by species plasticity. Further research work is needed to determine whether the relationships described above can be generalized.

Growth reaction of a multiple use species (*Tectona grandis* L. F.) to pruning in the State of Rondonia, Brazilian Amazon. Gama, M.B., Vieira, A.H., Rocha, R.B., Locatelli, M. (*EMBRAPA, Brazil; michelliny.bentes-gama@embrapa.br; abadio.vieira@embrapa.br; rodrigo.rocha@embrapa.br; marilia.locatelli@embrapa.br*).

Research on tropical silviculture practices is a key point for generating answers for forest managers and policy-makers. Especially in the Brazilian Amazon where complex biodiversity has experienced rapid degradation and the efforts on adjusting management techniques to encourage reforestation are permanent. Production forests may fit viable strategies to mitigate the negative effects of deforestation, but some driving characteristics for enhancing good wood quality are still needed. This study reported on the

pruning trial in a commercial plantation of teak in the State of Rondonia in northwestern Brazil. Treatments consisted of pruning intensities of 25%, 50%, and 75% and the control treatment with no pruning. Differences among treatments in pruning and age were not significant at 25% and 50% intensities in contrast to the control, but were significant at 75% intensity. In addition, the pruning intensities caused no detrimental effect on the commercial height of trees at the age of 44 months. Current findings indicate that moderate pruning regimes are adequate for pursuing improvements to stem form and wood quality without having a strong effect on tree growth and stand yield in this portion of the Amazon.

Evaluation of the effectiveness of the use of bokashi on seedling quality of *Balfourodendron riedelianum* (Engl.) Engl (Guatambu). Garcia, M., Zorrilla Benítez, S., Enciso Gomez, M., Vera de Ortiz, M. (*Universidad Nacional de Asunción, Paraguay; marialisgarcia@gmail.com; ser-zorro@hotmail.com; manuelenci@yahoo.com; dircif@agr.una.py*).

The growing demand for native tree seedlings requires research related to the use of substrates capable of providing seedlings with high initial growth rates and survival after planting. *Balfourodendron riedelianum* (Engl.) Engl (Guatambú) is a native species of Paraguay whose wood is in high demand both nationally and internationally. This study evaluated the effectiveness of bokashi on the quality of seedlings of Guatambú, with and without fertigation. The applied experimental design was a randomized factorial design with 14 treatments, 5 replicates, and a control. Each experimental unit consisted of four plants, totaling 300 seedlings. Morphological parameters including height, collar diameter, shoot dry weight, root dry weight, root shoot dry weight ratio, slenderness index, and Dickson quality index were evaluated. No significant differences in the levels of fertilization were found. The treatment consisting of soil (70%) + bokashi (30%) + fertigation produced the best results in height. In diameter and shoot root dry weight ratio, the best results were obtained with the substrate composed of soil (80%) + bokashi (20%) + fertigation. For slenderness index and Dickson quality index, the substrate composed of soil (50%) + bokashi (25%) + cow manure (25%) with fertigation produced the greatest value.

Enhancing mine and energy crop soils to promote willow and poplar growth using ash and biosolids: a greenhouse trial. Gilbert, N. (*International Forestry Students Association, Canada; sno_reason@inorbit.com*).

Wood ash from bioenergy production contains a high concentration of nutrients essential for plant growth and can neutralize acidity in soil. The objective of this study was to assess the growth of willow and poplar in soils amended with different amounts of bioenergy ash (0%, 0.5%, 1%, 2%). In two trials divided by soil type (sand and loam), clonal cuttings were grown in a greenhouse for 4 months. Three bioenergy ash differing in chemical properties, such as pH and CEC, and bioenergy system, boiler system versus gasifier, were used for this study. To supplement the nitrogen deficiency common of wood ash, biosolids were mixed into half the treatment samples. The acidic, well-draining, sandy soil produced the greatest yield of new growth in the mixed ash and biosolids combinations. In the neutral loam trial, the plants also responded best to the ash treatments mixed with biosolids. These results suggest a method of fertilization that not only promotes plant growth, but also provides a use for materials otherwise considered to be waste.

Advanced oak seedling development as influenced by shelterwood treatments, competition control, deer fencing, and prescribed fire. Gottschalk, K., Miller, G., Brose, P. (*U.S. Forest Service, USA; kgottschalk@fs.fed.us; gwmiller@fs.fed.us; pbrose@fs.fed.us*).

Advanced northern red oak (*Quercus rubra* L.) seedlings in an 85-year-old forest located in north-central Pennsylvania were observed for 10 years after manipulation of overstory density, herbicide control of interfering plants, exclusion of deer by fencing, and application of a single prescribed fire. A total of 24 treatment combinations including untreated controls were studied on 72 permanent plots. Seedling survival and seedling growth were enhanced by both exclusion of deer by fencing combined with a moderate (12% of basal area) to high (27% of basal area) removal of the overstory. Published dominance probabilities for site index 70 were applied to the average size and number of tagged advanced seedlings in each plot to determine which treatments produced the greatest predicted number of codominant oaks in the next stand after final harvest. Treatments that included exclusion of deer by fencing combined with a moderate (12% of basal area) to high (27% of basal area) removal of the overstory projected new stands with more than 50 percent oak composition. Fencing and no overstory removal, while producing much less growth, also predicted more than 50 percent oak composition. Oak seedling development and suggestions for writing silvicultural prescriptions to prepare for successful oak regeneration are discussed.

Mixed-species plantations of *Eucalyptus* and *Acacia mangium* as an alternative for bioenergy production in tropical regions. Hakamada, R. (*University of São Paulo, Brazil; rodrigo_hakamada@yahoo.com.br*), Bouillet, J. (*CIRAD, France; jean-pierre.bouillet@cirad.fr*), Gonçalves, J. (*University of São Paulo-ESALQ, Brazil; jlmgonca@usp.br*), Voigtlaender, M. (*Institute of Forest Research, Brazil; mvoigtlaender@gmail.com*), Gava, J. (*Suzano, Brazil; jgava@suzano.com.br*), Leite, F, Mareschal, L., Nouvellon, Y., Mazoumbou, J., Koutika, L., Epron, D., Laclau, J. (*CIRAD, France; jean-paul.laclau@cirad.fr*).

Silvicultural practices that increase wood production in forest plantations are required to achieve society's demand for renewable energy sources. Mixed-species plantations of *Eucalyptus* and *Acacia mangium*, a N-fixing species, have been studied as a pathway of ecological intensification, enhancing nitrogen availability and carbon accumulation within the system. Our objective was to compare the potential of bioenergy production in pure and mixed-species plantations. We used calorific values from the literature along with data of wood production measured at five sites in Brazil and Congo with various levels of productivity to calculate the energy produced at the end of stand rotation (on average 6.2 years after planting). We compared pure *Eucalyptus* stands (100E) to mixed-species stands with the same density of *Eucalyptus* trees with 25% *Acacia* trees (100E:25A). At all sites, the mixtures generated energy gains ranging from 0.2 to 36.3% compared to *Eucalyptus* monocultures. These gains were highly correlated (R^2>0.99) with total stemwood production, due to comparable calorific values for both species. This study opens the possibility for using mixed-species plantations of *Eucalyptus* with N-fixing tree species as a renewable source of bioenergy for both domestic and commercial uses.

Sustainability and profitability of a 2 year rotation in *Eucalyptus* for biomass production: case study in Brazil. Hakamada, R. (*University of São Paulo, Brazil; rodrigo_hakamada@yahoo.com.br*), Lemos, C. (*International Paper, Brazil; Cristiane.Lemos@ipaper.com*), Almeida, A. (*International Paper, Brazil; adriano.almeida@ipaper.com*).

Short rotation (SR) harvests of 2 years or less have been discussed in Brazil as a silvicultural system for producing biomass for energy. Although it is a way to grow biomass faster, sustainability and profitability of this system has been questioned. Our objective was to estimate the balance of nutrients and the costs of establishment, harvesting, and transportation of SR wood compared with a traditional system with 7 years rotation in *Eucalytpus*. We used results from Nelder design spacing trials to compare a traditional stocking with 1 545 trees/ha with a tighter planting with 7 150 trees/ha. Simulating a period of 70 years of cultivation, nitrogen, phosphorus, and potassium exportation was 53, 124, and 4% higher in SR. Establishment, harvesting, and transportation wood cost would be 192, 16, and 36% higher in SR. Land expected value, a measure that compares different duration investments, was 303% lower in SR, meaning lower profitability of this system compared with traditional stocking. Results indicated that even though it seems a faster way to acquire wood, in the long term it might be injurious for the soil nutrient balance and may not be profitable. Detailed methods for estimating nutrient exportation and costs will be presented.

Water deficit is a good predictor of maximum stocking in a *Eucalyptus* clonal plantation in Brazil. Hakamada, R. (*University of São Paulo, Brazil; rodrigo_hakamada@yahoo.com.br*), Lemos, C., Almeida, A., Silva, R., Batistuzzo, G. (*International Paper, Brazil; Cristiane.Lemos@ipaper.com; adriano.almeida@ipaper.com; renato.meulman@ipaper.com; guilherme.batistuzzo@ipaper.com*).

The choice of spacing is often made empirically, mainly in regions with no historical data of trees plantations. A wrong decision can cause the total mortality of a stand, and mortality usually is related to water constrains. The objective of this work was to create a tool which relates spacing decision with climate information. To do that, we planted four Nelder design trials with spacing varying from 228 to 7 150 trees/ha in different soil and climate conditions affecting water storage capacity, which permitted a variation in water deficit from 50 to 450 mm, calculated by the Thornthwaite and Mather method. We evaluated the stocking which could support more than 95% of survival in each site. We found a very strong relationship ($R^2 = 0.94$) between the water deficit and maximum stocking supported in each site. For areas with no water deficit, a stocking of more than 2 000 stems/ha was permitted, and this declined to less than 800 in areas with elevated water deficit. An increase of 100 mm of water deficit needs a decrease of 200–300 stems/ha. This tool provides some direction for making spacing decisions and uses information that groups soil and climate conditions.

Bioenergy and fiber use of bamboo biomass from small-scale plantations in Thailand. Haruthaithanasan, M., Darabant, A., Atkla, W., Phudphong, T., Thanavat, E., Haruthaithanasan, K., Wittayakarn, S. (*Kasetsart University, Thailand; aapmwt@gmail.com; darabant@gmail.com; dadida_62@hotmail.com); aaptpp@ku.ac.th; fgteak.t@gmail.com; aapksh@ku.ac.th; aapstr@ku.ac.th*).

In Thailand, farmers have recently begun establishing bamboo plantations on marginal land for possible utilization for bioenergy and fiber. This study looked at the potential of bamboo for biomass feedstock. First-year yield data of *Bambusa beecheyana* and *Dendrocalamus membranaceus* indicated vast differences between sites (1 vs. 18 t/ha), which is highly related to soil conditions and annual rainfall, but not between species. In terms of feedstock quality for power plants, high heating values (19.2 to 19.5 MJ/t) did not differ between species, but culm moisture contents did differ between species (51% for *B. beecheyana* vs. 45% for *D. membranaceus*) and between culm sections (38% wet base at top vs. 55% at bottom). This gradient was stronger in *D. membranaceus* which showed significantly higher moisture content in internodes as compared to nodes (46% vs. 43%). Fiber yield extracted from internodes of *D. membranaceus* was higher than that of *B. beecheyana* (alpha-cellulose content 46% vs. 36%), and fiber quality did not differ in spite of higher lignin content of *D. membranaceous* (23% vs. 16%). The chemical-free stem explosion method yielded higher quality fiber (in terms of fiber length, size, strength, and anti-bacterial properties) as compared to acidic and alkaline boiling. Our results provide guidance on increasing the value of bamboo biomass by optimizing the allotment of different species and biomass compartments to different uses (e.g., bioenergy, fibers).

Short rotation forestry in Bavaria (southern Germany): results of a survey of operators. Hauk, S., Wittkopf, S., Knoke, T. (*University of Applied Sciences Weihenstephan-Triesdorf, Germany; s.hauk@wz-straubing.de; stefan.wittkopf@hswt.de; knoke@forst.wzw.tum.de*).

The main focus of short rotation forestry (SRF) science has been basic research concentrating on results from experimental sites. Hence, about 1 200 hectares of SRFs in Bavaria (southern Germany) operated by normal farm practitioners have not yet been investigated, nor have the concerns and suggestions of these practitioners been documented. To fill these knowledge gaps, a standardized questionnaire was mailed to all SRF operators in Bavaria. The survey was designed to gather information about the land ownership and land use characteristics of SRF growers as well as the reasons they chose to cultivate SRF and the obstacles they face. SRF cultivation in Bavaria is practiced in a somewhat different manner than in northern Germany and the rest of Europe. Most SRF operators in Bavaria are part-time farmers cultivating poplar on small fields (on average 1.1 ha). In most cases, SRFs are cultivated in rotation periods of between 5 and 10 years on relatively poor and moist agricultural lands and harvested by chainsaw. Stems are dried in the open air and later used to cover the cultivators' heat demand. This extensive management practice is an interesting option for producing woody biomass on small-scale unfavorable agricultural lands.

Newly transplanted *Larix olgensis* Henry stock with greater root biomass has higher early nitrogen flux rate. He, X., He, X., Wang, W. (*Chinese Academy of Sciences, China; hexingyuan@iga.ac.cn; hexingyuan@neigae.ac.cn; wangwenjie@neigae.ac.cn*).

During wetland afforestation, information is quite limited about the relationship between initial tree stock status before transplanting and early nitrogen (N) flux in root. In this study, we pre-fertilized *Larix olgensis* Henry seedlings with three top-dress applications (NPK, 20-4-10) at rates of 0 (control), 31.58 (E-Low), 200 (E-Medium), and 525.08 (E-High) kg N/ha in a nursery

in Jilin, Northeast China. After being graded into large and medium sizes, overwinter stocks were transplanted into aerated distilled water or nutrient solution to detect early root N efflux or N influx, respectively. In large stocks, N influx tended to increase within 1 month in the E-Medium and E-High treatments where N efflux tended to rise as well. Root biomass in pretransplanted stock was linearly correlated with both N influx and N efflux for both stock sizes, but root N concentration was only correlated with N influx for large stocks. In conclusion, proper nursery fertilization could lead to appropriate seedling N reserves and greater root biomass resulting in a higher N influx rate for larger stocks, but roots would also risk more N efflux in humid, infertile sites shortly after planting.

Carbon storage capacity of monoculture and mixed-species plantations in subtropical China. He, Y. (*Chinese Academy of Forestry, China; hyjun163@163.com*), Qin, L. (*Guanzi University, China; nilniq@gxu.edu.cn*), Li, Z., Liang, X. (*Chinese Academy of Forestry, China; zyli1017@gmail.com*; *ecologystar@gmail.com*).

To evaluate the impacts of tree species compositions on the carbon storage capacity of plantation ecosystems, we measured the above and belowground biomass, as well as the carbon content, in three 27-year old forest plantations of monoculture *Castanopsis hystrix* (CH stand), monoculture *Pinus massoniana* (PM stand), and mixed *C. hystrix* and *P. massoniana* (mixed CH/PM stand) stands. The carbon storage levels of understory, litter, and soil components were also estimated. Results show that the ecosystem carbon storage of the mixed CH/PM stand (327 Mg/ha) was higher than those of the CH (315 Mg/ha) and PM (294 Mg/ha) stands. The majority of carbon storage was found in the soil pool. Almost 40% of soil carbon at a depth of 0–60 cm was stored in the upper 20 cm of the soil pool. Except for the vegetation layer, each layer of the CH and mixed CH/PM stands consisted of a higher amount of carbon than did the layers of the PM stand. These findings suggest that mixed CH/PM plantation stands or valuable indigenous CH plantation stands more substantially improve carbon storage in litter, soil, and ecosystems than do monoculture PM plantation stands.

Effect of nitrogen fertilization on morphological parameters of *Balmasocarpon brevifolium*, *Oxalis gigantean,* and *Balbisia peduncularis*: xerophytic species of importance in arid zones of Chile. Hernandez, J., Silva, S, Leon, P., Leon, M., Espejo, M. (*Instituto de Investigaciones Agropecuarias, Chile; jose.hernandez@inia.cl; sergio.silva@inia.cl; p.leon@inia.cl; mario.leon@inis.cl; mjose.espejocortes@inia.cl*).

Arid and semiarid regions cover approximately 30% of the Earth's surface yet have great importance in biological diversity. An example of this is the native and endemic flora found in northern Chile (29º53′ S 71º15′ W to 18°28′ S 7º21′ W), where we find a large number of species with serious conservation problems. In this context, the lack of existing knowledge about these species is transformed into a difficulty in deciding conservation measures, largely because of a lack of knowledge of the propagation process. Therefore, we studied the effect of nitrogen nutrition on growth of *Balmasocarpon brevifolium*, *Oxalis gigantea*, and *Balbisia peduncularis*. We used seeds collected from different altitudinal levels (m), and seedlings were subjected to different levels of nitrogen (0, 100, 300, and 500 mg/L) with the aim being to determine the effect of nitrogen fertilization on plant growth. To meet the objective, we recorded the height, diameter, and root biomass every 30 ± 1 days. As the nitrogen concentration increased in the growth medium, plant growth increased in *O. gigantea* and *B. peduncularis* ($P < 0.001$), with no effect of nitrogen on locust bean plants ($P > 0.05$).

Short-term responses of saproxylic insects to different types of forest restoration. Hjälten, J. Hägglund, R., Johansson, T., (*Swedish University of Agricultural Sciences, Sweden; joakim.hjalten@slu.se; ruaridh.hagglund@slu.se; therese.johansson@slu.se*), Dynesius, M. (*Umeå University, Sweden; mats.dynesius@emg.umu.se*) Roberge, J. (*Swedish University of Agricultural Sciences, Sweden; Jean-Michel.Roberge@slu.se*).

Intensive forest management has had severe impacts on forest biodiversity in many forest ecosystems. Thus, we have moved past a point where we can rely on passive conservation measures and must start assessing different methods for restoration of hitherto managed forests. The aim with this project was to evaluate ecological effects and cost efficiency of two different ecological restorations methods used in low-quality voluntary forest set-asides (prescribed burning and selective cutting conducted to resemble gap-dynamics), with non-restored stands serving as controls. We evaluated how these two restoration methods (which are currently developed and used in Swedish forestry) influenced a variety of organism groups (e.g., insects, fungi, bryophytes, vascular plants, and small mammals). The project was developed in close collaboration with representatives from the forest company Holmen Skog to ensure a potential rapid application of these restorations measures in various forest habitats if they are found effective. Immediate responses of saproxylic insects following burning and gap-cutting suggest fast responses of pyrophilous and fire favored beetles (e.g., *Melanophila acuminata*, and *Acmaeops pratensis*) to fire restoration. The response of other insect groups and the potential for large scale application of these types of restoration is discussed.

The characteristics of seedlings occurrence by different regeneration methods in a natural *Pinus densiflora* stand of South Korea. Hwang, J., Hyun Seop, K., Lee, K, Lee, S., Seo, K. (*Korea Forest Research Institute, Republic of Korea; jhwang@forest.go.kr; dendron@forest.go.kr; lkj0217@forest.go.kr; lst9953@forest.go.kr; kwseo@forest.go.kr*).

This study was carried out to understand the characteristics of seedling occurrence by regeneration method in a natural *Pinus densiflora* stand. Regeneration methods were divided into mother tree and clear-cutting. Seedling density and age were surveyed every 10 m in four directions (upper, lower, left, right) from the mother tree and in the lower direction of slope from the seed stand near clear-cutting sites. Seedling amounts by crown direction from the mother tree were 35% at lower direction, 25% to left, 22% to right, and 17% at upper direction. The seedling amount by distance from mother tree was 46% at 0 m (below crown) and 7% at 30 m from mother tree's crown. Results showed that seedling amount decreased with distance from the mother tree. The distribution of seedling age was from 2 to 5 years. However, more than 98% of seedlings occurred within 3 years after harvest. The characteristics of seedling occurrence by distance from seed stand in clear-cutting sites were 41% at 10 m, 32% at 20 m, and 12% at 40 m. Also, distribution of seedling age was from 2 to 9 years, and nearly 80% of seedlings appeared within 3 years after clear-cutting. These results will contribute to decisions regarding optimal placement of mother trees and size of regeneration area for secondary growth forest by natural seeding after harvest of *Pinus densiflora*.

The comparison of early growth of *Pinus koraiensis* seedlings in harvested deciduous and evergreen coniferous plantations. Hwang, J., Yang, A., Cho, M., Kim, S. (*Korea Forest Research Institute, Republic of Korea; jhwang@forest.go.kr; ramrami0130@gmail.com; mscho@forest.go.kr*, *ksk5409@forest.go.kr*).

This study was conducted to compare early growth of *Pinus koraiensis* seedlings planted in harvested *Larix kaempferi* (Chuncheon site) and *Pinus rigida* (Inje site) plantations in Gangwon, Korea. Containerized seedlings of *P. koraiensis* (2-2) were planted in both plantations in 2010. Two or three 400 m^2 plots were established in each study site, and 30 seedlings/plot were randomly selected for the measurement of seedling growth. Five soil (0–20 cm soil depth) samples were randomly collected in each plot in 2011 and were analyzed for soil properties. Each October from 2011 to 2013 we measured diameter at root collar and seedling height and then calculated relative growth rate (RGR) and the ratio of diameter at root collar to seedling height. Concentrations of soil total nitrogen, available phosphorus, organic matter, and cation exchange capacity at the Chuncheon site were significantly higher than those at the Inje site. The RGR of diameter at root collar at the Chuncheon site (30.4–37.0%) was higher than that of the Inje site (14.5–30.2%) every year. The RGR of seedling height at the Chuncheon site (48.2%) was significantly different compared to the Inje site (44.3%) in 2013. From these results, it is assumed that *P. koraiensis* seedlings in a harvested *L. kaempferi* plantation might show significantly higher early growth than that in harvested *P. rigida* plantation due to better soil conditions.

Variations in early seedling growth of *Quercus acutissima* in a strip cut *Larix kaempferi* plantation. Hwang, J., Yang, A., Cho, M., Lee, S. (*Korea Forest Research Institute, Republic of Korea; jhwang@forest.go.kr; ramrami0130@gmail.com; mscho@forest.go.kr; sg12612@forest.go.kr*).

This study was conducted to compare the early growth of *Quercus acutissima* seedlings in a strip cut *Larix kaempferi* plantation located in Boeun, Chungcheongbuk province, Korea. Strip cutting was performed using a 30 m width in the direction of contour. Bare-root seedlings of *Q. acutissima* (1-1) were planted at a density of 2 000 trees/ha in a strip cut *L. kaempferi* plantation in 2006. Three 400 m^2 plots were established in the edge and center of planted sites, respectively, and 30 seedlings/plot were randomly selected for the measurement of seedling growth. We measured diameter at root collar and seedling height each October from 2011 to 2013 using a folding scale and digital calipers and then calculated relative growth rate (RGR) and ratio of diameter at root collar to seedling height. The RGR of diameter at root collar in edge plots (16.9%) was significant higher than that in center plots (14.5%) in 2013. The RGR of seedling height in center plots (24.6–37.4%) was significantly higher than that in edge plots (22.6–32.5%) every year. From these results, it is possible to determine the appropriate width for strip cutting and management methods for regeneration in *Larix kaempferi* plantations.

Evaluation of the vegetation and proposal of species for rehabilitation of the Necropolis Cristóbal Colón patrimonial area in the Havana, Cuba. Jiménez Águila, M., Velazquez Viera, D., Sordo Olivera, L. (*Instituto de Investigacion Forestal, Cuba; mjimenez@forestales.co.cu; digna@forestales.co.cu; sordo@forestales.co.cu*).

The Necropolis Cristóbal Colón National Monument was declared due to the exceptional character of its historical and artistic securities. Since 1990, authorities, historians, restorers, and forest investigators have taken charge of veiling, to study and to disclose their patrimonial securities to maintain and to conserve the architectural beauty of monuments, gardeners, and the tree-lined cemetery, harmonizing the specific functions of the place. The objective was to evaluate the existing vegetation and to propose species to rehabilitate the patrimonial area to preserve the cultural memory. The inventory, diagnostic, and evaluation of the arboreal vegetation and shrubs of the area allowed species to be recommended for rehabilitating the green spaces in the main artery and other sections without affecting the monuments, streets, or sidewalks. Charts, pictures, designs and outlines were presented. An arboreal cover of 2 142 physical individuals was observed (trees and bushes). The prevailing species included *Ficus* sp., *Calophyllum antillanum* Britt., *Roystonea regia* (H.B.K.) O.F. Cook, and *Juniperus lucayana* Britt. Suggestions that contribute to elevating the cultural level and act to administer and manage the integral classification of the place and enlarge the interrelation between historical-cultural institutions and environmentalists are recommended for the rehabilitation and conservation of the specialized urban landscape.

Implementation of sustainable agroforestry in Mongolia. Jo, H., Park, H., Kim, J. (*Kangwon National University, Republic of Korea; jhk@kangwon.ac.kr; bhm63@knagwon.ac.kr; kjy84@kangwon.ac.kr*).

There is rising concern about desertification associated with drought, grazing, and deforestation in arid and semiarid regions. This study explored and implemented sustainable community agroforestry to combat desertification and to improve income in Elsentasarhai, Mongolia. Field and questionnaire surveys were conducted to determine growth environments and resident needs. Field surveys included tree planting techniques and growth conditions of the Desertification Research Center in Elsentasarhai and the Korea-Mongolia Greenbelt Project in Runsom. The questionnaire survey included what tree and income species should be planted as well as income level and life satisfaction. The majority of residents recommended *Ulmus pumila* and *Populus sibirica* as tree species to plant for desertification control. They also preferred cultivation of *Hippophae rhamnoides* and potato as income species. This study established a desirable agroforestry plan which was characterized by a combined land use system of tree plantings and crop cultivation. The plan was implemented around the Desertification Research Center in May 2013. The implementation is being monitored including parameters such as windbreak effect, soil moisture, tree vitality, and crop productivity.

Effects of soil amendments on survival rate and growth of *Populus sibirica* and *Ulmus pumila* seedlings in a semi-arid region, Mongolia. Jung, Y., Son, Y., Yoon, T., Han, S. (*Korea University, Republic of Korea; nayejee@gmail.com; yson@korea.ac.kr; bluemirror_@hanmail.net; saerom.han@gmail.com*), Kang, H. (*Dongguk University, Republic of Korea; HDK0225@dongguk.edur*), Yi, M. (*Kangwon National University, Republic of Korea; mjyi@kangwon.ac.kr*).

This study was conducted to investigate adequate soil amendments for a tree planting in a semi-arid region in Mongolia. *Populus sibirica* and *Ulmus pumila* seedlings were planted in alkaline sandy soils and treated with two levels of nitrogen, elemental sulfur, artificial moisture retention, and converted loess. After 4 months, the seedling survival rate of both species decreased as the amount of nitrogen increased. Nitrogen generally increases seedling survival rate and growth, however, the survival rate in this study might have be affected by an excess of nitrogen fertilization or by the microclimate, including the wind. The root collar

diameter (RCD) growth of both species increased significantly when treated with the converted loess, but only RCD growth of *P. sibirica* increased with the artificial moisture retention treatment. Although *P. sibirica* is drought tolerant, its growth depended on the capacity of available water. The elemental sulfur treatment showed no effect on the survival rate or RCD growth for either species due to the low oxidation of sulfur. Further studies are needed to examine the influence of nitrogen fertilization on seedling survival rate and growth for both species, and extended monitoring is also required to elucidate the long-term effects of soil amendments in this semi-arid region.

Effects of repeated whole-tree harvesting on soil properties and tree growth in a Norway spruce (*Picea abies* (L.) Karst.) stand. Kaarakka, L. (*University of Helsinki, Finland; lilli.kaarakka@helsinki.fi*).

Increased demand for forest-derived biomass has resulted in changes in harvest intensities in Finland. The Nordic countries have a long tradition of utilizing their forest resources intensively for both industry and energy purposes, and the use of forest-derived biomass for energy has steadily increased in the region during the past 15 years. Conventional stem-only harvest (SOH) has to some extent been replaced with whole-tree harvest (WTH). The latter involves a greater removal of nutrients from the forest ecosystem, as all the above ground biomass is exported from the site. This has raised concerns that WTH could result in large changes in the nutrient dynamics of a forest stand and could eventually lower its site productivity. The objective of this study was to assess the effects of repeated SOH and WTH on surface soil properties and stand growth in a fertile Norway spruce (*Picea abies* (L) *Karst*.) stand. The studied stand is part of a series of whole-tree thinning experiments established in Southern Finland. The results suggest that although the stand possesses significant pools of nutrients at present, WTH, if continued, could have long-term effects on site productivity.

Why bank on ban on felling for managing mountain forests sustainably? Kant, P. (*Institute of Green Economy, India; promode.kant@gmail.com*).

Himalayan forests hold 41% of India's growing stock, and community institutions in these hills have historically managed their forest resources reasonably well. The Forest Policy of 1988 is aimed at ensuring environmental stability and maintaining an ecological balance. Economic benefits must be subordinate to this principal aim, but increasingly rigid judicial interpretations of this principal have led to a near total harvesting ban in the hills, eroding the people's connection with the forests. Sustainable forest management can be defined as a coherent set of policies and practices under which the sum total forest capital stock of natural forests, manmade forests, and related institutional capital does not corrode over time and the natural forest capital itself does not dip below a critical threshold, even as the forests consistently enhance human welfare. The authors used national inventory data to estimate possible annual sustainable harvesting of 9.5 Mm^3 of timber and 3.8 Mm^3 of biomass-based fuel from these hills. This is almost twice the annual import of timber into India priced at US$ 2.6 billion, a substantial part of which would benefit the communities, generate employment, and increase climate change mitigation benefits. There are challenges to balancing competing ecosystems services, benefit transfer to remote stakeholders, and avoiding conflicts among neighboring communities over claims on forests.

Biodiversity and ecosystem services project in Cambodia. Khun, B. (*Biodiversity Conservation Corridors Cambodia, Cambodia; kbunnath@gmail.com*).

The design of the biodiversity corridors is embedded within a multipurpose, sustainable, biodiversity landscapes approach. The project will cover 22 communes (12 in Mondulkiri and 10 in Koh Kong) located across eight districts with a total population of approximately 68 048 (2008 census) in both provinces and households numbering just over 14 000. The project in both Koh Kong and Mondulkiri provinces is predominantly in mountainous areas covered with protected forests, national parks, and wildlife sanctuaries. An estimated 17 500 households will benefit from the project, of which about 25% are indigenous peoples of Mondulkiri largely from the Phnong group and 50% are women. The project will: (1) provide forest tenurial security to local communities and indigenous groups for collective management of forest resources; (2) restore habitat on degraded forest lands with tree planting of natives species and agroforestry models with improved sources of nontimber forest products; (3) improve livelihoods and income, enhancing small scale infrastructure; and (4) generate over 1 million cash-based labor days through project activities. Delineation and demarcation of these corridors will be in consultation with primary beneficiaries based on a participatory land use planning approach. Biodiversity corridors are geographic areas within or cutting across GMS economic corridors that need to be placed under sustainable management regimes to secure local livelihoods, address habitat fragmentation, and maintain ecosystem services.

The relationship between replanted tree growth and frequency of bush clearing in replanted Sugi (*Cryptomeria japonica*) forests. Kitahara, F. (*Forestry and Forest Products Research Institue, Japan; bunsho@ffpri.affrc.go.jp*).

Recently, it has become important to reconsider low-cost silviculture for effective replanting in Japan. In this study, the relationship between replanted tree growth (tree height and diameter) and frequency of bush clearing in replanted Sugi (*Cryptomeria japonica*) forests was evaluated. The results showed that the amount of weeds affected tree height growth and bush clearing affected tree diameter growth. The reporting and comparison of further experiments of bush clearing and growth surveys is encouraged.

Short-term effects of whole tree and stem-only harvesting on C and N fluxes in two *Picea abies* stands, Norway. Kjønaas, O., Clarke, N., Eldhuset, T., Hanssen, K., Hietala, A., Lange, H., Nordbakken, J., Økland, T., Røsberg, I. (*Norwegian Forest and Landscape Institute, Norway; janne.kjonaas@skogoglandskap.no; nicholas.clarke@skogoglandskap.no; elt@skogoglandskap.no; kjersti.hanssen@skogoglandskap.no; ari.hietala@skogoglandskap.no; holger.lange@skogoglandskap.no; jfn@skogoglandskap.no; tonje.okland@skogoglandskap.no; ingvald.rosberg@skogoglandskap.no*).

As the Norwegian government plans to increase use of bioenergy from harvest residues in order to reduce the need for fossil fuels, we need to know the short- and long-term consequences for the forest ecosystem. In 2008 and 2010, we established field experiments at Gaupen (SE Norway) and Vindberg (SW Norway) to compare the effects of whole-tree (WTH) and stem-only

(SOH) harvesting on tree and ground vegetation litter input and microclimatic factors and their effects on decomposition of new litter and soil organic matter, fungal community structure, and nutrient losses. We weighed selected trees and logging residues, surveyed understory biomass production, quantified soil C and nutrient pools down to 30 cm, and deployed litterbags. Soil water, soil respiration, temperature, and moisture were measured monthly. Fungal sequencing was performed, and organic and mineral horizons were incubated at different temperatures to estimate potential C and N mineralization. Long-term changes in the soil C pool depend on the balance between the decomposition rates of soil organic matter, input of litter from ground vegetation, and the contribution of slash to the buildup of humus. We will present a synthesis of C and N fluxes and discuss differences between the SOH and WTH harvesting.

Phenology observation of *Macaranga tanarius* in four regions in peninsular Malaysia. Koter, R. (*Forest Research Institute Malaysia, Malaysia; rosdi@frim.gov.my*).

Monitoring phenology is important when managing the collection of matured seed. Not many studies focus on phenology of pioneer species such as *Macaranga tanarius*. It is importance to investigate the phenology pattern of the species to better manage seed collection and planting material. The phenology of *M. tanarius* was observed during April 2012 until September 2013 at four regions, namely Central, East Coast, Northern, and Southern. At each region, four trees of *M. tanarius* were selected, and new shoot, flower bud, blooming flower, falling flower, fruiting set, young fruit, mature fruit, and falling fruit were recorded. Two flowering seasons were observed with the first period peaking from February to April and the second peaking from June to September. Most trees flowered at the beginning and fruited at the end of the first peak, but some flowered during the end of the first peak and fruited during the second peak. The most abundant flowers collected determine the specificity of the phase experience by the mother plant. The plants took 2 to 3 weeks to complete the fruiting phase. The seed collection can be made when fruits are fully ripened.

Responses in physiology and growth of minor central European tree species to drought events. Kunz, J., Löffler, G., Räder, A., Bauhus, J. (*University of Freiburg, Germany; joerg.kunz@waldbau.uni-freiburg.de; gemaloe@web.de; annemarie.raeder@web.de; juergen.bauhus@waldbau.uni-freiburg.de*).

To adapt European forests to climate change, it has been suggested to increase tree species diversity and the proportion of drought tolerant species. Regionally, forest area covered by economically important tree species might be further reduced by increasing incidences and severity of droughts. Currently, neglected broadleaved species such as *Sorbus torminalis*, *S. domestica*, *Acer campestre*, and *A. platanoides*, which are being regarded as drought-tolerant, may offer suitable silvicultural alternatives; however there is little reliable information about their responses to drought. Here, we examined the resistance to and recovery from drought of seedlings and mature trees using physiological and dendrochronological approaches. Water was withheld from seedlings of the above tree species and their common associates *Fagus sylvatica* and *Quercus petraea* in greenhouse and outdoors experiments. Measurements of physiological performance of unwatered individuals compared to well-watered individuals showed varying responses to withstand water shortage. *A. campestre* seemed to be best adapted to drought. Additionally, the response of mature trees to drought was examined through tree-ring analyses. While *Q. petraea* appeared to be the most drought-resistant species, *S. domestica* appeared to recover most quickly from drought. Our results indicated that minor broadleave species have the potential to enrich species diversity in forests on drought-prone sites.

Short-rotation forestry with hybrid aspen in hemiboreal Estonia: implications for forest management, science, and society based on 15-year experience. Lutter, R. (*Estonian University of Life Sciences, Estonia; reimo.lutter@emu.ee)*, Tullus, A. (*University of Tartu, Estonia; arvo.tullus@ut.ee*), Tullus, T. (*Estonian University of Life Sciences, Estonia; tea.tullus@emu.ee)*, Kanal, A. (*University of Tartu, Estonia; arno.kanal@ut.ee*), Tullus, H. (*Estonian University of Life Sciences, Estonia; hardi.tullus@emu.ee*).

Short-rotation forestry (SRF) is a new silvicultural concept in hemiboreal Estonia. One of the most promising tree species for SRF in northern Europe is hybrid aspen (*Populus tremula* L. × *P. tremuloides* Michx.). In Estonia, the first hybrid aspen plantations for the production of pulpwood were established in 1999 on abandoned agricultural land. A network of 80 long-term experimental plots in hybrid aspen, and for comparison also in silver birch (*Betula pendula* Roth) plantations, was created to study ecology and management of SRF with these species. By now the studied hybrid aspen plantations have passed two-thirds of a 25-year rotation period. Growth and productivity of 15-year-old hybrid aspen plantations exceeds most local tree species at this age. Hydrophysical properties, rather than nutrient stocks from past fertilization of abandoned agricultural soils, have been decisive for the growth rate of the trees in young plantations. Economic calculations indicate that SRF with hybrid aspen is an economically profitable use for areas where agricultural land use has ceased. The main damages in young hybrid aspen plantations have been moose browsing and stemwood infestation by poplar longhorn beetles. To conclude, hybrid aspen has proved to be an economically and ecologically suitable tree species for afforestation of abandoned agricultural lands.

Trade-offs between utilizing fine woody debris and minimizing rotation time in hybrid poplar plantations. McCavour, M. (*Concordia University & Université de Québec à Montreal, Canada; mccavour@gmail.com*), Paré, D. (*Canadian Forest Service, Canada; David.Pare@RNCan-NRCan.gc.ca*), Messier, C. (*Université du Québec en Outaouais, Canada; ch.messier@gmail.com*), Thiffault, E. (*Canadian Forest Service, Canada; Evelyne.Thiffault@RNCan-NRCan.gc.ca*), Thiffault, N. (*Ministère des Ressources naturelles du Québec, Canada; nelson.thiffault@mrn.gouv.qc.ca).*

Forest harvest residue (FHR) may be utilized as an alternative energy source. A hidden cost however, is the lengthened rotation time if trees grow more slowly due to reduced nutrient input. Our objectives were to: (1) examine soil nutrition, tree wood volume, and foliar nutrient status of hybrid poplar (*Populus maximowiczii x P. balsamifera*) as a function of proximity to slash pile; and (2) estimate the block-scale poplar yield loss at year 7 if all FHR were removed. Using two 7-year-old poplar plantations on sandy loam in Quebec, we found that poplar relative growth rate was faster nearer to the piles, and semi-log correlations of tree volume and soil and foliar nutrients on distance from pile were significant and inverse, with little effect >10 m. The accrual of wood biomass by pile-propinquous trees more than compensated for loss in planting space. We estimate a block-wide reduction of 20% by age 7 if piles had been removed in year 1. Given that the rotation for hybrid poplar for this site is 20 years,

slash retention will lead to a dramatic shortening of the rotation interval. The tradeoffs for policy and management of retaining some or all FHR within the block are discussed.

Growth, biomass accumulation, and functionality of *Gmelina arborea* (L.) Roxb. in climate change scenarios for Colombia. Melo Cruz, O. (*University of Tolima, Colombia; omelo@ut.edu.co*), Martínez Bustamante, E., Rodríguez Santos, N. (*Universidad Nacional de Colombia, Colombia; enmartin@unal.edu.co; natha8902@hotmail.com*).

Gmelina is a tropical tree from Asia that is widely used in industrial-scale plantations in the tropical dry forests of Colombia. A total of 30 even-aged stands between 3 and 7 years old were evaluated on 10 sites located across a precipitation gradient that varied between 900 and 1 800 mm/yr. Circular plots of 500 m^2 were established and monitored for 3 years. DBH (cm), total height (m), and crown radius (m) were recorded. Biomass per functional component (leaves, branches, trunk, root) was determined. Finally, the net assimilation rate, transpiration, stomatal conductance, water use efficiency, and photosynthetically active radiation (PAR) were assessed. A direct correlation between the growth rate and the medium annual precipitation was found. Growth rates varied between 8 and 19 m^3/ha/yr. When water was provided in order to avoid a hydric deficit, growth exceeded 25 m^3/ha/yr. The functional compartment with the highest accumulation of dry matter was the trunk with 42.5%, followed by the branches with 23.8%, the roots with 21.1%, and the leaves with 12.6%. There was a positive correlation between the growth and the net assimilation of CO_2 which exceeded 30 µmol/m^2/seg in conditions without hydric stress (field capacity) and 14 µmol/m^2/seg on sites with the lowest precipitation.

Effects of organic matter removal and nitrogen and carbon leaching fluxes in Douglas-fir plantation. Menegale, M., Harrison, R. (*University of Washington, USA; marcism@uw.edu; robh@uw.edu*), Holub, S. (*Weyerhaueser Co., USA; Scott.Holub@weyerhaeuser.com*), Guerrini, I.A. (*São Paulo State University, Brazil; iguerrini@fca.unesp.br*).

The increasing interest in energy production from woody biomass may possibly affect the uptake of carbon and nitrogen in soil due to the removal of branches and foliage during timber harvesting. This study aimed to look at the influence of organic matter removal during timber harvest. Specifically, how does the presence/absence of harvest debris (such as chips, branches) influence the accumulation of nutrients in the soil and, consequently, the final productivity of a Douglas-fir plantation? The experiment was installed in the Mackenzie River watershed, Eugene, OR, in a tree farm owned by Weyerhaeuser Company. The total area has 20 plots, with 1 acre in each plot. Three types of harvest were conducted in the different plots: bole-only harvest, total-tree harvest, and total-tree harvest plus forest floor removal, as well as soil compaction in combination with these treatments. Lysimeters were installed in the treatment plots and samples are collected once a month at 20 cm and 100 cm depths in order to measure the concentration of nutrients leached along the soil profile. Samples will be analyzed for soil alkalinity, dissolved inorganic carbon (DIC), dissolved organic carbon (DOC), and dissolved organic nitrogen (DON), as well as macronutrients and micronutrients, and results will be presented.

Fate of applied ^{15}N fertilizer in a Douglas-fir plantation. Michelsen-Correa, S., Harrison, R. (*University of Washington, USA; smcorrea@uw.edu; robh@uw.edu*).

As the predominant forest plantation species in the Pacific Northwest, Douglas-fir (*Pseudotsuga menziesii*) and the productivity of its underlying soil are important to the sustainability of the region's timber economy and forest health. Nitrogen (N) is known to be a limiting nutrient in Douglas-fir ecosystems. Previous studies have found that N fertilization can increase tree growth when applied to low productivity sites. However, of the total N fertilizer applied, less than 30% is taken up by the surrounding trees. A better understanding of the fate of the remaining N is necessary to mitigate any potential environmental impacts and increase the financial return of fertilizer applications. The results of a study that seeks to detect enrichment of ^{15}N beyond the boundary of a 100 m^2 treatment plot is presented here. A target tree was selected and treated with 0.5% ^{15}N applied at a rate of 224 kg N/ha. Forest floor and mineral soil (15 cm depth) were sampled along transects radiating from the base of the target tree in each of the four cardinal directions to 2.5 m beyond the fertilizer boundary. Additionally, one foliage sample was taken from the closest tree (>3 cm DBH) along these transects. These samples can track the fate of N moving beyond the boundaries of the application area.

Dominance probabilities for oak seedlings in Pennsylvania: variation in seedling size and ecological sections affects seedling success. Miller, G., Gottschalk, K., Brose, P. (*U.S. Forest Service, USA; gwmiller@fs.fed.us; kgottschalk@fs.fed.us; pbrose@fs.fed.us*).

A study was designed to determine the survival and dominance probabilities of oak advanced regeneration for 5, 7, and 10 years after final removal cuts by ecological classification. A total of 31 stands and 6 235 tagged seedlings in four ecological sections were included. Advanced oak seedlings were classified based on their initial root collar diameter. The larger the initial size of the seedling, the taller the 5-, 7-, and 10-year old stem and the higher its dominance probability. Free-to-grow, a more conservative measure than total height, produced lower probabilities. It is still too early to define reliable dominance probabilities because stands have not reached crown closure. Interim results indicated that probabilities were declining from year 5 to year 7 to year 10. Free-to-grow values were also declining over time and may be a better measure of long-term success. The Blue Ridge Mountains section appears to successfully regenerate oak with smaller seedlings compared to other areas of the state, but this difference decreased from year 5 to year 7 to year 10 and may eventually disappear.

Which management under climate change? An assessment of the provisioning of ecosystem services in mountain forests. Mina, M., Bugmann, H., Cailleret, M. (*ETH Zurich, Switzerland; marco.mina@usys.ethz.ch; harald.bugmann@env.ethz.ch; maxime.cailleret@usys.ethz.ch*).

In mountain areas, forests are of crucial importance for the provision of multiple ecosystem services (ES). In a fast changing environment, this can only be maintained if forest managers take into consideration the sensitivity and adaptability of these ecosystems. Forest succession models are important tools to assess whether adverse climate change effects on ES can be counteracted by adaptive management. We evaluate whether business-as-usual management (BAU) can still provide multiple ES in European mountain forests under climate change or if adaptive management regimes need to be applied to match this objective. A climate-sensitive forest succession model (ForClim) was improved and applied in five case study areas across European

mountains using different management regimes and climate change scenarios based on new algorithms for capturing specific harvesting regimes. A set of up-to-date and novel indicator-based approaches were used for assessing the provisioning of ES. Simulation results revealed that in certain regions, climate change is likely to have negative effects on most ES, but these effects can be mitigated by adaptive management, while in other sites such changes in management strategies would not be sufficient to maintain the desired level of ES.

Growth and nutrient dynamics of plantation forest of *Eucalyptus* hybrid as raw material for pulp industry in Indonesia. Mindawati, N. (*FORDA, Indonesia; ninapulp@yahoo.co.id*), Indrawan, A., Mansur, I., Rusdiana, O. (*Bogor Agriculture University, Indonesia; andrecol1@yahoo.com; irdikam@gmail.com*; *O_rusdiana@yahoo.com*).

The objective of this research was to study growth and nutrient dynamics of *Eucalyptus urograndis*. This research used field data collected in the first and second rotation. Research results showed that at 5 years of age, stand growth in the first rotation reached a volume of 159.89 m^3/ha, whereas in the second rotation volume was 142.49 m^3/ha. Maximum volume in the first rotation was reached at age 5.4 years and in the second rotation at age 6 years. With a cutting rotation of 5 years, nutrient balance was predicted to be negative after the end of the first rotation. With a cutting rotation of 6 years, nutrient balances of N, K, and Ca were positive only at the end of rotation 1. At a cutting rotation of 7 years, nutrient balances of N, K, and Ca had been negative since the end of rotation 1. Quality of site with cutting rotation of 5 years decreased more rapidly as compared with 6 and 7 years. Fertilizer application and several silvicultural techniques are required for recovery of sites and nutrient balance. It could be suggested that the optimum rotation for *E. urograndis* in fertisol soil is 6 years.

Initial yield of biomass production in wood energy plantations in the Guanacaste Province, Costa Rica. Molina Quesada, S., Esquivel, E., Arias, D., Briceño-Elizondo, E. (*Instituto Tecnológico de Costa Rica, Costa Rica; samolina117@gmail.com; eesquivel@itcr.ac.cr; darias@itcr.ac.cr; ebriceno@itcr.ac.cr*).

With an increase in energy demand, a steady sustainable supply of energy is of increasing importance for emerging countries. At the same time, industrialized countries are proposing changes in traditional energy sources and shifting towards zero emission alternatives. Energy from forest biomass provides an important option in degraded areas with limited water supply. In a collaboration between a private enterprise (Taboga) and a public university (Technological Institute of Costa Rica), high density plantations were established at selected sites. Taboga generates power from sugar cane bagasse, however, this crop is seasonal, and the company needs a complementary supply during the off season. To determine the performance of high-density plantations, a three-block experimental design was established using six treatments, combining two species (*Gliricidia sepium* and *Gmelina arborea*) and three stocking densities (5 000, 10 000 and 20 000 trees/ha). Soil nutrients, biomass accumulation, and individual carbon storage in soil was periodically evaluated in 900 m^2 plots. After a year of growth, evidence of differentiated yields per treatment was achieved, preliminarily suggesting the more favorable species and density, knowledge of great importance for Taboga and other energy consuming companies.

Experimental forests: an anchor in a changing scientific world. Moser, W. (*U.S., Forest Service, USA; moserk@safnet.org*).

Individual trees in forested ecosystems generally outlive the professional careers of those who study them. If we are to continue to expand our understanding of the patterns and processes of these ecological assemblages, we need consecutive generations of researchers to study, discover, and pass on their knowledge to succeeding scientists. This process benefits from having a focal point that connects research around a location or theme that transcends time and events. The U.S. Department of Agriculture, Forest Service's experimental forests were formed so that research could be conducted with a focus on management possibilities over the long range, insulated from short-term management constraints. This paper will present examples of long-term research that provides insight into the questions facing resource professionals today and potential approaches, even though the original research questions posed had very different objectives and expected implications. Our examples will illustrate how long-term data from experimental forests, born in an era of more utilitarian intent, can help address today's questions about the expected impacts of potentially different climate and disturbance regimes.

Variations of vegetation biodiversity in a wild pistachio forest among different altitudinal levels: case study. Negahdarsaber, M. (*Research Institute of Forests and Rangelands, Iran; siamaksaber@hotmail.com*).

This research investigates the biodiversity of vegetation in a wild pistachio forest, south Zagros, Fars Province, Iran. This semi-arid cold region has xerofluvent soil with a calcareous origin and a community of trees including mainly *Pistacia atlantica, Amygdalus scoparia, A. ebornea, A. lycioides,* and *Acer monspessolanum*. The area of the study site was 9 374 ha. A list of bush, shrub, and tree species and their abundance was recorded during sampling trips in spring 2013. The area was divided into three altitudinal levels (level 1: <1 800 m, level 2: 1 800–2 000 m, and level 3: >2 000 m above sea level (a.s.l.)). Species diversity, evenness, and richness indices were calculated and analyzed using PAST 2.17. Results showed that species diversity, evenness, and richness indices of level <2 000 m a.s.l were higher than the other levels while levels >1800 m and 1 800–2 000 m a.s.l were not significantly different. It can be suggested that enrichment programs including seed and shoot planting might be more effective in areas with altitude <2 000 meter a.s.l in this region, compared to other elevations.

Height growth of Korean pine saplings planted under strip-cut larch plantations in northeast China. Owari, T., Tatsumi, S. (*University of Tokyo, Japan; owari@uf.a.u-tokyo.ac.jp; jeyms23@gmail.com*), Ning, L. (*Dabiangou Forest Farm of Qingyuan County, China; yinssssjp@yahoo.co.jp*), Yin, M. (*Shenyang Agriculture University, China; yinssss@163.com*).

To enhance ecosystem functioning while maintaining the economic benefits of larch plantations, a pressing need exists to develop alternative forest management regimes in northeast China. Two-storied forest management in which overstory larch trees are strip-cut and Korean pine (*Pinus koraiensis* Sieb. et Zucc.) saplings are under-planted has been deemed a viable option. However, limited knowledge exists on the growth patterns of Korean pine saplings planted under strip-cut larch plantations. This study examined the height growth of Korean pine saplings planted under the larch canopy openings created by different types of

strip-cutting treatments in northeast China. We used a generalized linear mixed model to quantify the sapling height growth of under-planted Korean pine. The derived growth model predicted a 39–45% reduction in annual height growth for the narrowest strip-cuts (4.5 m) versus the open site (i.e., a site with no canopy), while a 17–33% reduction in annual height growth was predicted for the wider strip-cuts (6.0–7.5 m) versus the open site. To maintain adequate height growth, it is recommended that forest managers create wider strip-cuts (i.e., ≥6.0 m) for the purpose of under-planting Korean pine saplings in larch plantations.

Variation throughout the year of N^2-fixation of *Acacia mangium* in pure stand or in association with *Eucalyptus grandis*. Paula, R.R., (*University of São Paulo, Brazil; ranieri@usp.br*), Bouillet, J. (*CIRAD, France; jean-pierre.bouillet@cirad.fr*), Gonçalves, J. (*University of São Paulo, Brazil; jlmgonca@usp.br*), Laclau, J. (*CIRAD, France; jean-paul.laclau@cirad.fr*. Trivelin, P.O. (*University of São Paulo, Brazil; pcotrive@cena.usp.br*).

N_2-fixation by leguminous trees can be an important source of nitrogen in forest plantations, but little is known about its seasonal variations. We estimated N_2-fixation by *Acacia mangium* growing in pure stands (100A) and in association with *Eucalyptus grandis* (50A:50E) in Brazil. At 27 months of age, we applied ammonium sulphate (99.8 atom % ^{15}N) diluted in water (1.1 kg N/ha) to the litter. Every 3 months during one year we selected four trees per species in each treatment and collected all the leaves from two branches distributed in each third of the canopy. The average percent of N derived from fixation (%Ndfa) was 70.3±5.2% and 48.1±10.8% in 50A:50E and in 100A, respectively. The higher %Ndfa in mixture could be due to lower soil N availability than in 100A and to strong competition of *Eucalyptus* over *Acacia* for soil N uptake. The highest and lowest values of %Ndfa were observed at the end and at the beginning of the rainy season, respectively. N_2-fixation showed lower seasonal variations in 50A:50E than in 100A. In this last treatment, %Ndfa was about 30% higher at the end of the rainy season than during other periods.

Analysis of seedling production in forest nurseries in the Alto Paraná District of Paraguay. Perdomo Rolón, M. (*Instituto Forestal Nacional, Paraguay; titaperdomo@hotmail.com*).

In order to obtain good results in a forest plantation, it is of utmost importance to use high-quality forest reproductive material. The present study was aimed at analyzing the seedling production in the forest nurseries of the Departamento Alto Paraná by means of personal interviews. It turned out that 91% of the nurseries included in the study produced seedlings exclusively from seeds and 9% performed clonal propagation. The majority of producers preferred seed collection. In certain zones of the district, only 8% acquired certified seeds from the National Forest Institute. The native species with the highest production was *Handroanthus impetiginosus* (Mart. ex DC.) Mattos which was present in 73% of the nurseries considered in the study. Among introduced species, production was highest for *Eucalyptus grandis* Hill ex Maiden which was present in 86% of the nurseries. The study found evidence of a high potential for seedling production and of the need to establish a control mechanism for the production of seedlings with better genetic qualities and safe provenance. In addition, the importance of complementing such a mechanism with a system to support producers was identified in order to improve production.

Tropical dry forests aboveground biomass measurements in West Africa, Abdoulaye Wildlife Reserve (Togo). Pereki, H. *(University of Lome, Togo and Hamburg University of Applied Sciences, Germany; pereki@daad-alumni.de*), Wala, K. (*University of Lomé, Togo; kpwala75@yahoo.fr*), Thiel-Clemen, T. (*Hamburg University of Applied Sciences, Germany; thomas.thiel-clemen@haw-hamburg.de*), Bessike Balinga, M., Zida, M. (*Center for International Forestry Research (CIFOR), Burkina Faso; mpbalinga@yahoo.fr; m.zida@cgiar.org*), Dourma, M., Akpagana, K. (*University of Lomé, Togo; dourmamarra@yahoo.fr; koffi2100@gmail.com*).

In West Africa, researchers typically focus on forest diversity assessment and structure without regards to biomass measurements and carbon cycling. To address this issue, we evaluated and quantify tree biomass in Abdoulaye Wildlife Reserve in Togo. Tree height, diameter at breast height, and crown diameter were collected in 157 Modified-Whittaker plots (20 m × 50 m). We performed a one-way ANOVA with Tukey's honest significant difference multiple comparisons computation. The highest density was recorded for *Anogeissus leiocarpa* individuals. Thus, we specified its dendrometric parameter as a control and applied Dunnett's general linear model method. Results showed significantly that dense dry forests recorded higher aboveground density (54.88%) than the other vegetation types. Aboveground biomass density per plant species varied between 1.156 ± 0.123 and 8.64 ± 0.001 Mg/ha. Stem biomass density (12.35 ± 1.33 Mg/ha) recorded the highest value ($P < 0.001$), whereas biomass densities of branches and leaves were 2.59 ± 0.26 Mg/ha and 0.41 ± 0.04 Mg/ha, respectively. Matrix scatterplots reported a positive significant quadratic relationship ($P < 0.001$). The highest R^2 of the regression ranged from 95.2 to 99.5% of the curvatures and confirms this close allometric correlation.

Effects of different harvesting intensities on the macronutrient pools in aged oak coppice forests. Pyttel, P., Bauhus, J., Köhn, M. (*University Freiburg, Germany; patrick.pyttel@waldbau.uni-freiburg.de; juergen.bauhus@waldbau.uni-freiburg.de; merlekoehn@gmx.de*).

Improved knowledge concerning nutrient removals through harvesting in former coppice forests is crucial for the sustainable management of these forests. This is especially true if the resumption of coppicing is being considered to serve increasing fuel wood demands. In this study, the nutrient contents of various tree compartments of sessile oak (*Quercus petraea* (Mattuschka) Liebl.) and hornbeam (*Carpinus betulus* L.) were determined to calculate the nutrients removed under different harvesting intensities. Independent of site and species, the highest nutrient concentrations were found in twigs and stem bark. Simple power functions to predict the nutrient content in the various tree parts showed high coefficients of determination ($R^2 = 0.51$ to 0.98). The comparison between the amount of nutrients stored in tree biomass and in soil indicated that sustainable nutrient management must consider different harvesting intensities according to site type. On sites with large soil nutrient pools, even whole trees can be harvested without causing deleterious effects. However, on sites with a low nutrient capital, current harvesting practices would result in high rates of nutrient export, and therefore exploitation of soil pools. In these stands, harvesting intensity should be based on careful selection of the tree compartments removed to conserve nutrients on site.

Can tree-fall gap characteristics be used to improve forest management? A case study in the virgin Hyrcanian forest in northern Iran. Rahbari Sisakht, S., Moayeri, M. (*Gorgan University of Agricultural Sciences & Natural Resources, Iran; rahbari.saeed@gmail.com; Moayeri@yahoo.com*).

Virgin forests in northern Iran provide a unique opportunity to study the disturbance regimes of forest ecosystems without human influence. The aim of this study was to determine relationships between size, shape, and the spatial pattern of tree-fall gaps and regeneration using ecological principles. This study was carried out in three compartments (15, 18, and 19) of a virgin forest in northern Iran. Tree-fall gaps, size, location, and regeneration were measured in all three compartments. One-way ANOVA was used to compare gap features and regeneration. Spearman's rank correlation coefficient was used to test the relationship between gap size and regeneration density. The results showed that total opened area in the three compartments was 13.72 ha (7.4%), and on average there were 1.06 gaps per hectare. The size of opened area averaged 658.2 m^2. Most gaps (69.2%) ranged between 200 to 1 000 m^2. Results of spatial pattern analysis showed uniform and irregular shapes for gaps in three compartments. ANOVA analysis showed that there was statistical significant difference between gap size and regeneration number. Also the Spearman's rank correlation showed direct relativity between gap size and regeneration, and when gap size increased, number of seedlings also increased. These results can be used with ecological forestry principles to improve forest management.

Wood carbon storage in a semidecidual seasonal secondary fragment in the Atlantic Forest domain in Brazil over 20 years. Reis, M.F., Reis, G., Souza, F., Caliman, J. (*Universidade Federal de Viçosa, Brazil; mgfreis@ufv.br; greis@ufv.br; felippe.souza@ufv.br; jpcaliman@gmail.com*), Oliveira, C. (Espirito Santo State University, Brazil; *carlos.oliveira@ifes.edu.br*). Amorim, J. (*Universidade Federal de Viçosa, Brazil; junio.amorim@ufv.br*).

The Atlantic Forest, one of the biodiversity hotspots, encompasses thousands of small and degraded fragments in varying successional stages that may be capable of sequestering and storing carbon. This study aimed to evaluate the carbon sequestration potential in two sites with different successional stages in a fragment of a semidecidual seasonal forest in the Atlantic Forest domain in Brazil over a 20 year period. Diameter and height were measured for all tree individuals with diameters over 10 cm, and volume was obtained with a nondestructive method. The available information for wood density for each species was used to estimate wood biomass. Carbon storage was obtained by multiplying the biomass by 0.5. The carbon storage in the site with the most advanced stage of succession was 70.85 t/ha in 1992, and there was an increase of 50.9% in 20 years. In the site at an initial stage of succession, the stored carbon increased 178.3% in the same period, starting from 17.68 t/ha. These results indicate the importance of the secondary forest fragments in the Atlantic Forest domain in reducing the impacts of greenhouse gas emissions.

Characterizing aspen regeneration by presence of ungulates, topography, and tree species composition. Rhodes, A., St. Clair, S., Wan, H. (*Brigham Young University, USA; aaron.rhodes0@gmail.com; samuel_stclair@byu.edu; hoyiwan@gmail.com*).

High ungulate densities in forest ecosystems change tree species composition and lead to drastic changes in plant and animal communities. In many aspen forests, wildlife management policies and extirpation of natural predators have allowed historically high ungulate densities. Aspen is considered a preferred browse species of elk and deer and is an important forage for cattle. While the degraded state of aspen in many regions of North America is recognized, the effects of herbivory by species type on aspen regeneration are understudied. Further, stand tree species composition and topographical features such as elevation, slope, and aspect may predict successful aspen forest regeneration. The objective of this study was to characterize the impact of herbivory across broad geographical ranges and track aspen regeneration as a function of ungulate density, stand type, and topographical features. Using GIS, we extracted topographical features at each site. We evaluated aspen basal shoot height and density using AIC model selection as a function of stand type, ungulate density, slope, elevation, and aspect. We found that high elevation was a strong predictor of aspen suckering density and height. We found that the presence of deer and cattle was correlated with the lower height of aspen suckering, which may prevent recruitment into the overstory.

Environmental limitations to natural regeneration in a restored seasonally dry tropical forest. Sangsupan, H., Hibbs, D., Withrow-Robinson, B. (*Oregon State University, USA; hathai.sangsupan@oregonstate.edu; david.hibbs@oregonstate.edu; brad.w-r@oregonstate.edu*).

Seasonally dry tropical forests (SDTF) have become the world's most threatened tropical terrestrial ecosystem in large part because of its widespread conversion to agricultural land. Today, millions of hectares of converted SDTF land have been degraded and abandoned. Active intervention is required for forest recovery in many of these areas. Although promising restoration techniques are being tested, the environmental factors limiting natural regeneration in restored SDTFs are not yet well understood. To address this gap, we will present the results of a 3-year longitudinal investigation of the relationship between potential limiting environmental factors (i.e., light, soil moisture, and soil nutrients) and naturally recruited seedlings in the understory of a restored SDTF in northern Thailand. We will also present results from an experiment investigating why, even after many years, seedlings of tree species common to adjacent intact forest remain absent from reforested areas. This study tested the hypothesis that the seeds of absent species experience unfavorable microenvironmental conditions that prevent germination and establishment in the restored forest. Results suggest that seedling establishment is not dependent upon the tested understory microenvironmental conditions. Instead, seed dispersal limitations or species-specific early survival strategies may determine species presence or absence in restored forest.

Carbon contents in *Acacia mearnsii* De Wild. plantations. Sanquetta, C., Corte, A.D., Ruza, M., Pscheidt, H., Behling, A. (*Federal University of Paraná, Brazil; carlos_sanquetta@hotmail.com; anapaulacorte@gmail.com; marielisabrina93@gmail.com; heloisaa_p@yahoo.com.br; alexandre.behling@yahoo.com.br*).

The objective of this paper was to study the carbon content in *Acacia mearnsii* De Wild. (black wattle) plantations throughout its farming cycle. Moreover, the implications of using values found in the literature or using a default value were assessed. The study was conducted in a stand of black wattle with ages ranging from 1 to 7 years. The t-test was used to compare measured values of carbon content with values found in the literature and also with the default value of 50%. Carbon content for leaves, bark, branches, and wood averaged 48.1, 45.8, 45.4, and 44.1%. The t-test values were significant, indicating that the observed values

differed from the ones found in literature and the default one. The use of the default value of 50% generated lower α values for bark and wood in all the studied ages, while for other compartments the α values varied. In conclusion, using default values for carbon stock estimations introduced errors that resulted in significant differences from observed values. Therefore, it is recommended that specific values should be used whenever possible.

Epicormic potential of common eastern North American oak species. Saunders, M., Meier, A. (*Purdue University, USA; msaunder@purdue.edu; ameier@purdue.edu*).

In many perennial woody plants, epicormic branches allow plants to respond quickly to changing environmental conditions and rebuild leaf area in response to significant injury. However, epicormic branches cause significant wood quality degradation in many fine hardwood species that are being grown for veneer and other high value products. In many tree improvement programs, there is a strong impetus to understand the influence of genetics and tree vigor on epicormic development. Using both a controlled crown pruning and thinning experiment and two descriptive studies, one with computed tomography (CT) scanning of destructively sampled logs and the other a field survey after harvesting, we described epicormic development in several oak species. Our results suggested that tree vigor had a stronger and more direct role on epicormic development than genetics in pole-sized white oak (*Quercus alba*) individuals, although we suspect that genetics impacts epicormic composition through its effects on sequential branching patterns early in a tree's life. In sawlog-sized trees, epicormic development was related to both species and tree size, but vigorous trees that were free from epicormic branches prior to silvicultural treatment generally do not form epicormics within the lower log. We conclude with discussion of future research needs on epicormic branching.

The effect of increasing biomass demands on forest management in Central Europe. Schumann, C., Pyttel, P. (*University of Applied Science Weihenstephan-Triesdorf, Germany; christina.schumann@hswt.de; patrick.pyttel@hswt.de*), Unseld, R., Weich, T. (*University of Applied Forest Sciences Rottenburg, Germany; ruediger.unseld@waldbau.uni-freiburg.de; thomas.weich@waldbau.uni-freiburg.de*).

Forests play a key role in current German energy policy. Besides rising energy prices, the increasing pressure on forest ecosystems as potential sources of bioenergy is fostered by improvements in harvesting and utilization techniques. To meet the targets for bioenergy production, various silvicultural approaches were developed and are now available for forest owners and practitioners. However, the impact of renewable energy policy on forest management practices and related consequences for nature conservation strategies are largely unknown. Our aim is to investigate how an increasing biomass demand is altering silvicultural decisions, management plans, and harvesting intensities in Central European forests. A questionnaire-based survey was carried out in four federal states of Germany comprising different stakeholders from the forest sector. Our findings indicated an intensification of the use of harvest residues and thinning intensities, especially in stands consisting of broad-leafed tree species. Additionally, traditional forms of forest management (e.g., coppice and coppice with standards) are regaining more importance.

Successional dynamics of community structure and species diversity after clear-cutting of *Abies faxoniana* forest stands. Shi, Z., Cheng, R. (*Chinese Academy of Forestry, China; shizm@caf.ac.cn; chengrm@caf.ac.cn*).

In order to clarify the recovery processes after clear-cutting sub-alpine *Abies faxoniana* forest stands, dynamics of community structure and species diversity at different successional stages (10, 20, 30, 40, and 50 years) were studied. The results showed that size classes of trees in the successional stages of 20–50 years showed reverse J-shaped distributions, with samples mainly distributed in the small-sized and medium-sized classes. Successional stages were classified into three types based on the importance value of dominant species: (1) *Rubus* and *Rosa* shrubs, (2) *Betula* broad-leaved forests, and (3) conifer and broadleaf mixed forests. Shannon-Wiener diversity indices of arbor and shrub layer species increased while the index of herb layer species decreased with succession time. Pielou's evenness indices of the species in all three layers increased with succession time. Simpson's dominance index of arbor layer species decreased with succession time, while the indices of shrub and herb layer species increased within 0–40 years of the succession and decreased at the successional stage of 50 years. Light-demanding pioneer tree species such as *B. albo-sinensis* that regenerated after logging would be replaced by more competitive climax species such as *A. faxoniana,* and thus relayed floristic change along the secondary succession.

Effects of artificial pruning on growth in young plantations of *Nothofagus* in south-central Chile. Soto, D. (*Oregon State University, USA; daniel.soto@oregonstate.edu*), Donoso, P. (*Universidad Austral de Chile, Chile; pdonoso@uach.cl*).

Nothofagus dombeyi and *N. alpina* are highly valuable tree species in Chile. Both species grow rapidly when planted in open fields but have shown problems with forking of the leading branches at early stages, thus artificial pruning may be necessary. To evaluate the effects of pruning on growth, we assessed the temporal effects of artificial green pruning on growth of young plantations with these species. A block design was installed for each species, and we evaluated the effects of pruning on the absolute growth rate (AGR) of diameter at breath height (DBH), height (h), and individual volume index (v). The treatments were: (1) stem pruning (at one third of total height) and top pruning (leaving one leader in forked trees) (BTP); (2) top-pruning (TP); and (3) control. The results showed that BTP had stronger detrimental effects on DBH AGR in *N. dombeyi* after 4 years. In contrast, the height AGR was not influenced by pruning treatments. *Nothofagus alpina* was not affected by pruning treatments. Despite DBH AGR in *N. dombeyi* being affected by BTP, artificial pruning is highly recommended in order to improve the quality of the stems and increase the clearwood production in these highly valuable species.

Selecting cold-hardy *Eucalyptus* species for the Southeastern United States using a regionwide network: 4-years results. Stape, J. (*North Carolina State University, USA; jlstape@ncsu.edu; kbhall2@ncsu.edu*), Fox, T. (*Virginia Tech, USA; trfox@vt.edu)*, Rubilar, R. (*University of Concepción, Chile; rrubilar@ncsfnc.cfr.ncsu.edu*), Albaugh, T. (*Virginia Tech, USA; tim_albaugh@vt.edu*), Alvares, C. (*Institute of Forestry and Education, Brazil; clayton@ipef.com*), Hall, K. (*North Carolina State University, USA; kbhall2@ncsu.edu*).

Eucalyptus species are widely used for wood production across the world, but not in the Southeastern United States, except for the southernmost part of Florida which has a warmer climate. In the last few years, *Eucalyptus* plantations outside of Florida

have been considered given the species potential to be managed as a short rotation woody crop system with coppice. However, this implementation depends on answering fundamental questions like: (1) Which Eucalyptus species can thrive in the Southeastern winters? (2) What are the silvicultural protocols that lead to adequate forest productivity for the different site conditions? and (3) Besides frost, are there other weather-related risks or pest and disease risks? These questions are being addressed by the Forest Productivity Cooperative using a network with 36 *Eucalyptus* trials planted across 18 sites in the Southeast in the spring of 2010, 2011, 2012, and 2013. Frost damage and growth evaluations occurred in April/May of each year together with pests and diseases assessment. The 4-years results of the network will be presented, including the genotype x environmental interactions, yield potential for the cold-hardy species, and the silvicultural and nutrition demands.

Assisted natural regeneration in degraded dry monsoon forests with the participation of rural people in Sri Lanka. Suduhakuruge, B. (*Forest Deparment, Sri Lanka; bandumala03@yahoo.com*).

Most of the natural dry monsoon forests in Sri Lanka have been degraded and converted into open forests through various processes such as shifting cultivation, illegal timber harvesting, forest fire, and development projects. Sri Lanka's Forest Department has taken many attempts to upgrade these degraded lands into productive forests through planting of local timber tree species. Highly eroded and unfertile soils together with the annual fire hazards have retarded the growth and survival of these planted seedlings, wasting government funds. This study investigated the possibility of accelerating the growth of already existing seedlings through the participation of people from areas adjacent to the forest. The study started in 2008 in a dry monsoon forest which initially had approximately 800 trees/ha. The area was highly covered with grasses and was subjected annually to manmade forest fires. People's participation involved establishing and maintaining the fire lines around the study area and encouraging growth of existing tree seedling by removing grasses. Results showed that when compared with conventional tree planting programs, this method was highly cost effective and successful, while generating an income to the adjacent people.

The technological properties of plantation grown mahogany in Ghana: Are they inferior to naturally grown ones? Tekpetey, S., Opuni Frimpong, E., Appiah-Kubi, E., Essien, C. (*Forestry Research Institute of Ghana, Ghana; nii9lartey@gmail.com; eopunifr@mtu.edu*); *appiahkemma@yahoo.com; caessien@ymail.com*).

The dwindling forest cover in many countries coupled with the increasing demand for timber and other wood products has necessitated the redirection of efforts by both government and nongovernmental agencies to increase forest cover and availability of raw materials for their timber industries. Plantation forestry, using both exotic and indigenous tree species, is being expanded in the tropics and other regions. It is estimated that about 4.6 million hectares of tropical plantation exist in tropical Africa. Khaya species are among the indigenous tree species of value that have been introduced into plantations in Ghana. In this study, five trees of plantation grown mahogany (PGM) and three trees of naturally grown mahogany (NGM) were extracted from Pra-Anum Forest Reserves, Ghana. The technological properties that were assessed were lumber quality, machining and mechanical properties, kiln drying characteristics, and sliced veneer quality from both PGM and NGM. Results revealed that values for modulus of rupture ranged between 60–70 N/mm^2 with good kiln drying characteristics and moderately good planing, sanding, and sliced veneer quality. It was concluded and recommended that the properties of plantation grown mahogany trees in Ghana were not inferior to that of naturally grown mahogany in Ghana.

Use of lignocellulosic biomass as biofuel: a key for a sustainable future. Tewari, V.P. (*Institute of Wood Science and Technology, India; vptewari@yahoo.com*).

Using crops to make liquid fuel is not a new idea. Biofuels are not only preferable to petrol, but there is also hope for biofuels' environmental and social redemption. The International Energy Agency has laid out a roadmap to ramp-up the use of biofuels from around 2% of global transport fuel today to 27% by the year 2050. Each year, more than 40 million tonnes of inedible plant material, including wheat stems, corn stover, and wood shavings from logging, are produced. Turning these discarded, woody bits of plants into second-generation biofuels has huge appeal. Two important methods involved in tapping this second generation biofuel from lignocellulosic wastes are biochemical and thermochemical methods. Among these, thermochemical methods coupled with the Fischer-Tropsch process reaction paves the way to liquid fuel which can readily be used by present spark engines. Fast-growing species can be grown on polluted soil, which also helps to reduce soil contamination. These trees convert carbon dioxide into biomass more rapidly than most other plants. To avoid energy crops vying with food crops for land use requires careful selection of species. Advanced biofuels hold promise of an escape from their predecessors' food-versus-fuel conundrum and are a key to reducing our fossil fuel dependence.

How can *Macrotermes* termites provide ecosystem services in a savanna woodland in Burkina Faso, West Africa. Traoré, S. (*Université Polytechnique de Bobo, Burkina Faso; sarantraore_2003@yahoo.fr*), Ouédraogo, J. (*Institut de l'Environnement et de Recherches Agricoles (INERA-CNRST), Burkina Faso; tinsibiri_ouedraogo@yahoo.fr*), Sita, G. (*Université de Ouagadougou, Burkina Faso; sguinko@univ-ouaga.bf*), Lepage, M. (*Institut de Recherche pour le Développement (IRD), Burkina Faso; michelglepage@orange.fr*).

Savannas in tropical zones experience recurring bush fires and herbivore disturbances that can alter soil carbon and nitrogen budgets, vegetation, and soil macrofauna. *Macrotermes* termites can also influence soil organic matter, flora, and plant growth. This study carried out in Tiogo forest was aimed at assessing the effects of *Macrotermes subhyalinus* on soil carbon and nitrogen budgets under controlled grazing and fire regimen in 16 subplots (50 m × 50 m) of which 8 were burned annually and 8 were protected from fire since 1992. The mean annual rainfall between 2002 and 2005 was 840±82 mm. Vegetation was dominated by grass species *Andropogon pseudapricus* and *A. gayanus* and woody families Mimosaceae and Combretaceae. A total of 48 composite soil samples were collected from 0–30 cm deep on and adjacent to mounds to quantify carbon and nitrogen content. Results indicated that *Macrotermes* termites store a large amount of carbon and nitrogen in mounds (1.88±0.37%; 0.15±0.03%) compared to adjacent areas (0.82±0.27%; 0.08±0.01%) while fire and/or grazing had no significant effects on soil carbon or nitrogen. Woody parameters were positively correlated to carbon and nitrogen amounts. As an ecosystem service, termite mounds provided carbon and nitrogen which are significant benefits for a savanna functioning to ensure woody species recovery, multiple taxa conservation, and valuable timber production at a small-scale in managed areas.

Growth characteristic of *Ulmus pumila* L. seedlings from different seed sources in Mongolia. Tsedensodnom, E. (*Institute of Geoecology, Mongolia; enkhii_smile@yahoo.com*), Nyam-Osor, B. (*National University of Mongolia, Mongolia; bnyamosor@yahoo.com*), Tsogtbaatar, J. (*Mongolia; tsogtbaatarj@magicnet.mn*).

Ulmus pumila L. is distributed across Mongolia, including in arid and semiarid regions, and has excellent drought tolerance that enables it to survive under soil water deficits for long and short periods of time. The aim of this study was to determine growth and physiological characteristics of *U. pumila* seedlings grown from different seed sources in Mongolia. Seeds were collected from seven mother trees from three geographical locations including Northern: Selenge province (Orkhun river, Ustai shaamar, Khuurai shaamar), Central: Bulgan province (Elsentasarkhai), Southern: Umnugobi province (Planted tree, Dalanzadgad, Bayankhoshuu). Seeds were sown in the greenhouse and seedling growth and physiological parameters (shoot length, root collar diameter, leaf area, leaf biomass, specific leaf area, relative chlorophyll content) were monitored. Significant differences in shoot length, root collar diameter, and relative chlorophyll content were observed among seed sources. Leaf biomass, leaf area, and specific leaf area did not differ significantly. A significant correlation between leaf area and relative chlorophyll content was apparent in all seed sources. Specific leaf area was reduced in seed sources from dry regions (Dalanzadgad, Shaamar) but increased in semi-arid regions (Elsentasarkhai, Ustai shaamar) which may explain adaptation mechanisms of mother trees in drought conditions.

Salt tolerance of *Ulmus pumila* L. seedlings from geographycally different seed sources. Tsedensodnom, E. (*Institute of Geoecology, Mongolia; enkhii_smile@yahoo.com*), Nyam-Osor, B. (*National University of Mongolia, Mongolia; bnyamosor@yahoo.com*).

Increasing salinity is one of the inhibiting factors of plant growth and production in arid and semiarid regions of Mongolia. The objectives of this study were to investigate effects of salinity on leaf area, leaf biomass, specific leaf area, and relative chlorophyll content of *Ulmus pumila* L. Seeds were collected from three regions in Mongolia: Northern (Selenge province), Central (Bulgan province), and Southern (Umnugobi provinces). The experiment was conducted in the greenhouse, and seedlings were grown in two different soil types: river sand and soil conditions. Three different salt treatments using solutions containing 2 200, 5 100 and 6 900 mg/L of dissolved salts (NaCl, $MgSO_4$, and $CaCl_2$) were applied. Research results revealed that all measured variables were reduced as salt concentrations increased. Two-year-old seedlings of different seed sources of *U. pumila* survived under treatments with salt concentration of 2 200–5 100 mg/l (4.36–10.4 dS/m) which confirms their high salt tolerance. However, combined effects of soil type and leaching capacity of soils had a combined effect on salt tolerance of seedlings, negatively affecting seedling growth and biomass accumulation.

Modelling effects of desertification control measures on the China Tibetan Plateau. Wang, X. Luo, Q., Hao, Y. (*Chinese Academy of Forestry, China; wxq@caf.ac.cn; luqi@caf.ac.cn; hyuguang@163.com*).

The Shazhuyu desertification control demonstration zone was established in the alpine sand lands on the Tibet Plateau in the 1960s. It contains a 1000 hm^2 core area now used for technology distribution and demonstrations of the desertification control projects of the surrounding region. The site promotes the formation of an oasis protection system which is composed of an artificial sand-barrier zone, enclosure and range-land restoration zone, afforestation zone and farmland shelterbelt zone from west to east along the main wind direction in the regional distribution. The objective of this study was to evaluate the ecological effects of desertification control measures in the demonstration zone. A methodological approach was designed to evaluate the ecological impact at the regional scale over a 50-year period, analyzing and identifying the technical characteristics of the demonstration zone. The analysis of this impact was carried out from both statistical and qualitative perspectives. Long-term monitoring and focused research show that with the increase in number of years of sand-fixing and vegetation restoration, vegetation conditions have markedly improved. According to the fixation years of 1964, 1977, 1986, and 2013, the total vegetation coverage reached 83%, 75%, 68%, 8%, respectively. Biomass of herbs was 68.82 g/m^2, 63.45 g/m^2, 38.11 g/m^2, 14.3 g/m^2. Physical and chemical properties of soil have improved.

Initial effects of crop tree release treatment on carbon stocks in a southern China Chinese fir plantation. Wang, Y., Wu, J., Yang, Y., Gu, C. (*Zhejiang A & F University, China; w_yixiang@126.com; 593037927@qq.com; yangyi52314@126.com; Gu_cuihua@126.com*).

The purpose of this study was to evaluate the effect of crop tree release (CTR) on carbon dynamics in even-aged Chinese fir plantations in southern China. A comparison of treated and untreated plots over two growth seasons showed that: (1) the carbon increment of a single crop tree and a general tree in treatments plots were higher than that in control plots (4.25±0.35 kg, 1.57±0.04 kg, 3.27±0.66 kg, and 1.09±0.07 kg, respectively); (2) carbon in soil, shrubs, and grasses was not impacted by CTR; (3) carbon in the tree layer decreased 9.90 t C/ha immediately after CTR and increased to 3.98 t C/ha while values were 3.46 t C/ha in the control; (4) carbon in litter and coarse woody debris (CWD) increased 0.92±0.67 t C/ha and 0.89±0.17 t C/ha in treatment plots, significantly higher than that of control plots; (5) reduced carbon in treatment plots was hypothesized to be kept in harvested wood products and added as tree layer carbon, and it showed that the carbon of tree layer in treatments plots was 11.16 t C/ha higher than that in control plots; and (6) carbon equivalent emissions associated with CTR such as transportation were small compared to the magnitude of the net C sequestration of the tree layer.

Volume or biomass? evaluating tradeoffs in aboveground live tree growth across a range of wood density in temperate forests of the eastern United States. Woodall, C. (*U.S. Forest Service, USA; cwoodall@fs.fed.us*).

The emerging paradigm of trait-based ecology (versus species-based) provides an opportunity to refine our understanding of forest productivity dynamics in light of recent global interest in managing forests for bioenergy feed stocks or carbon sequestration. The goal of this study was to examine trends in forest aboveground volume/biomass production as related to tree wood density using a region-wide repeated forest inventory across eastern U.S. forests. Using quantile regression, it was found that the 90th percentile of volume/biomass accretion was negatively related to the mean wood specific gravity of a stand's constituent tree species. When

managing forest stands for biomass/carbon accretion, it suggested that foresters consider the volume versus biomass tradeoffs when selecting tree species (i.e., using functional traits such as wood density in a decision support system) especially in lightly stocked stands on sites with a large number of growing degree days.

Effects of nitrogen deposition on growth and phosphate efficiency of *Schima superba* of different provenances grown in phosphorus-barren soil. Zhang, R., Zhou, Z. (*Chinese Academy of Forestry, China; ruirui0218@126.com; cafzzc@126.com*), Luo, W. (*Forestry Seed Administration of Zhejiang Provenance, China; zmzlwj@126.com*).

It was determined whether nitrogen (N) deposition on phosphorus (P)-limited soil could increase *Schima superba* growth or alter root formation or P efficiency. The effects of N deposition on *S. superba* were also used to investigate the N/P requirements of plants of different provenances. One-year-old *S. superba* seedlings from eight geographic areas were grown in P-limited soil and treated with 0, 50, 100, or 200 kg N/ha/yr, hereafter designated as control, N50, N100, or N200, respectively. Seedling growth, root development, phosphorus acquisition efficiency (PAE), and phosphorus utilization efficiency (PUE) were measured. *S. superba* responded positively to N supplementation. Seedling growth and dry biomass were highest when treated with N100 and lowest with N200. Root biomass and acquisition of soil P were greatest with N100. Significant differences were observed among plants of different geographical provenances. PAE and PUE each had a strong relationship with root growth in plants subjected to N100 treatment. A threshold for N and P requirements related to different genetic conditions and soil nutrients may exist for *S. superba*. Root growth and PAE can be divided into three categories based on soil nitrate levels. Nutrients were found to control root morphology and to enhance aboveground differences.

Nutrient evaluation and DRIS diagnosis of young teak (*Tectona grandis* L.f.) plantations in acid soil in south China. Zhou, Z., Liang, K., Huang, G., Ma, H. (*Chinese Academy of Forestry, China; zzzhou@ritf.ac.cn; lkn@ritf.ac.cn; huanggh@ritf.ac.cn; fjmhm@163.com*).

Teak (*Tectona grandis* Linn f.) is one of the most well-known timber species in the world and has been introduced to many countries and regions due to its great market demand and high economic, ecological, and social value. In recent decades, teak has rapidly been established in south China. However, about 60% of the soils in the planted areas are acidic to severely acidic. In order to sustainably meet present and future demands for teak timber, a better understanding of the nutrient dynamics and nutrient demands and norms of both trees and soils is vital for the plantations growing in acid soils in south China as well as for those established on the consequential acidified regions affected by global atmospheric pollution and acid deposition in other countries. Investigations in 19 representative teak plantations aged 5–8 years old under different site conditions were conducted. The results indicated that mean annual volume increment was positively correlated with N, Ca, Fe, Zn, and B concentration in leaves and with soil available P concentration and base saturation percentage. Diagnosis and Recommendation Integrated System (DRIS) indicated that the nutrient balance of Ca with Mg, Fe, and Al was the key to promote teak growth in acid soils in south China.

Strategies and practices to grow non-wood forest product species in degraded hilly area of southern China. Zhou, Z., Liang, K., Huang, G., Ma, H. (*Chinese Academy of Forestry, China; zzzhou@ritf.ac.cn; lkn@ritf.ac.cn; huanggh@ritf.ac.cn; fjmhm@163.com*).

Large areas of degraded secondary forests in southern China are classified into ecological forests and are characterized by low ecological function and economic value. Local communities that depend on these forests have become poverty-stricken because the livelihood-based products from the forests are becoming unavailable. Management strategies and practices to rehabilitate the degraded forests in a sustainable way are urgently needed. A pilot demonstration study in growing species of market-driven non-wood forest products is being conducted in Lianghua Forest Farm, Huidong County, Guangdong Province. The objective of the study is to find available rehabilitation means to achieve the tradeoffs between environmental protection, economic development, biodiversity, and sustainable livelihood by intercropping non-wood forest product (NWFP) species. More than ten species with high market value or potential from edible fruits, tea, and medicines extracted from leaves and branches have been planted. Initial surveys indicated that the survival rate of the NWFP species intercropped in the forest alley was over 85%.

GENERAL POSTER SESSIONS

IUFRO Division 2: Physiology and Genetics

Impact of Biochar Soil Amendment on Growth and Physiology of Tree Saplings. Abdollahi, K. (*Southern University, USA; kamrana664@cs.com*).

Biochar from gasification of wood waste in Louisiana was used as a soil amendment in a randomized complete block design study to quantify the impact of biochar soil treatment on the growth and physiology of live oak saplings. Height, diameter growth, net photosynthesis, respiration, and transpiration of live oak saplings were measured one growing season being treated with the biochar soil amendment. In addition, the impact of biochar on the chemical properties of the soil was quantified. The results indicated statistically significant impacts on growth and physiology of live oak saplings treated by biochar soil amendment. Some chemical soil properties were significantly impacted by the biochar amendment.

Heritability of height and diameter for six-year-old *Shorea leprosula*. Abdullah, M.Z. (*Forest Research Institute Malaysia (FRIM), Malaysia; zaky@frim.gov.my*).

Shorea leprosula, commonly known as light red meranti, is one of the better known and most economically valued timbers in Malaysia. Wood density ranges from 425–685 kg/m³. As a general utility timber, it is commonly used for joinery, utility furniture, shop and office fittings, showcases, counter tops, paneling, ceiling, shelving, cabin fittings, fence, boxes, fabricated coffins, light-duty flooring, and interior partitions. Trees are still produced from natural forest. Up to now, the planting materials still come from seeds collected mostly from unknown seed sources, and there is still no available seed orchard for *S. leprosula*. In order to provide genetically improved seeds of *S. leprosula*, a seed orchard progeny test of this species has been established in Ulu Sedili Forest Reserve (FR) and Kemasul Forest Reserve. Seeds (open pollinated) were collected from 40+ trees located in five forest reserves. Trees were selected based on stem persistence, stem straightness, branch size, circularity, free from pest and disease infections, and clear bole height. The trials were laid out using a randomized complete block design (RCBD) with eight replications. Within each plot for each replicate, 160 trees in two rows were planted at a 4 m × 4 m spacing. The performance of progeny tests at 6 years indicated that there were significant differences in height and diameter for all families observed, and some families, such as family No. 5 and No. 14, seemed to show good phenotypes on the test locations. Estimations of heritability for height were moderate on both sites ($h^2 = 0.12$ in Ulu Sedili FR and $h^2 = 0.18$ in Kemasul FR). Meanwhile, the results for heritability of diameter were low in Kemasul FR ($h^2 = 0.06$) and moderate at Ulu Sedili FR ($h^2 = 0.17$). This indicates that the genetic factor contributes more to determining these two characteristics than the environmental factor.

Mycorrhiza enhanced growth and heavy metal tolerance of *Acacia mangium*, *A. aulacocarpa,* and *Swietenia macrophylla* in minewaste soil. Aggangan, N. (*University of the Philippines Los Banos, Philippines; nelly_aggangan@yahoo.com*), Aggangan, R. (*Forest Products Research and Development Institute, Philippines; raggangan@yahoo.com*).

A screenhouse experiment was conducted to determine growth and heavy metal tolerance of three fast growing tree species, *Acacia mangium, A. aulacocarpa and Swietenia macrophylla,* in minewaste soil and to determine the ameliorating effect of mycorrhizal fungi. Aseptically germinated seedlings were either uninoculated or inoculated with arbuscular mycorrhizal fungi (*Gigaspora margarita, Glomus etunicatum*, Mykovam, a commercial mycorrhizal inoculant and mycorrhizal fungi from mine sites coded as Paracale isolates) during pricking and grown first in commercial potting medium. After 2 months, seedlings were transferred to mine waste soil. Mine waste soil was collected in Paracale, Camarines Norte and was characterized as very acidic (pH 3.5) and contained 1 262 mg Pb/kg, 12.87 mg Cd/kg, 3.51 mg Cu/kg and 1.44 mg Zn/kg. Four months after the transfer, all the mycorrhizal seedlings showed greater height and biomass and took up more Cu than the uninoculated counterpart. The best growth was obtained from those inoculated with the Paracale isolates (isolated from mine waste sites). Mykovam inoculated plants gave the highest P and Cu uptakes. In conclusion, the commercial mycorrhizal inoculant Mykovam and Paracale isolates enhanced the heavy metal tolerance of the three fast growing tree species and could be used for the rehabilitation and reforestation of heavy metal contaminated areas in the Philippines.

Slow release fertilizer and mycorrhizal inoculum potential effective for *Acacia mangium* under nursery conditions. Aggangan, N. (*University of the Philippines Los Banos, Philippines; nelly_aggangan@yahoo.com*), Aggangan, R. (*Forest Products Research and Development Institute, Philippines; raggangan@yahoo.com*).

A nursery experiment was conducted to determine the best combination of slow release fertilizer and mycorrhizal inoculum potential effective for *Acacia mangium*. Aseptically pre-germinated seedlings were inoculated with 23 to 230 spores/plant during pricking. Mycorrhizal inoculants included a mixture of eight species belonging to the genera: *Glomus*, *Gigaspora*, *Scutellospora*, *Acaulospora,* and *Entrophosphora*. Seedlings grown in polybags (250 g oven sterilized medium) were applied at five rates (0–2 g/plant) of NPK slow release fertilizer (14-14-14 Osmocote) 2 inches below the soil surface. Results show that fertilizer level and mycorrhizal inoculum potential and their combination have significant effects on growth of *A. mangium*. The tallest and largest diameter was obtained at 0.50 g/plant. Three mycorrhiza treatments promoted the greatest height and stem diameter while two treatments resulted in lower values than the control. The control plants showed increasing height and stem diameter even up to 2 g/plant while all the mycorrhiza treated counterparts had their highest height and stem diameter at 0.5 g/plant. Growth of non-mycorrhizal plants at 2.0 g NPK/plant was similar to that obtained by mycorrhizal plants at 0.25–0.5 g NPK/plant. In conclusion, mycorrhizal inoculum potential below 230 spores/plant in combination with 0.5 g NPK/plant was the best protocol for producing healthy *A. mangium* for use in nursery rehabilitation programs.

Effect of pre-treatment and sowing media on germination of *Tetrapleura tetraptera* (Schum. & Thonn) seeds. Akinyele, A., Onasanya, O. (*University of Ibadan Nigeria; akinyelejo@yahoo.co.uk; tee1980boy@yahoo.com*).

This study investigated the effects of pre-treatments and sowing media on germination of *Tetrapleura tetraptera* seeds. A total of 420 *T. tetraptera* seeds were pre-treated by soaking in boiled water (T1), sowing directly into topsoil (control (T2)), soaking in water for 24 hours at ambient temperature (T3), and soaking in different concentrations of hydrochloric acid (HCL) (10 mg/L (T4), 15 mg/L (T5), 20 mg/L (T6), and 25 mg/L (T7)). Riversand (S1), topsoil (S2), and sawdust (S3) were used as sowing media. Cumulative germination counts were recorded for 12 weeks. Least Significant Difference (LSD) was used to separate significant means. Epigeal germination was first observed in S1 after 3 days. Pre-treatment, sowing media, and interaction between pre-treatment and sowing media were significantly different ($p<0.05$). T2 using S1 medium had 85% germination. Rate of germination was faster in riversand than topsoil medium. Zero germination was recorded in seeds pretreated with HCL at 20 mg/L and 25 mg/L sown in sawdust. *Tetrapleura tetraptera seeds* were easily germinated without any pre-treatment using both river sand and top soil. However, further research could be carried out on the effects of different pre-treatments on this species to further enhance its productivity.

Effect of different watering regimes on germination and early seedling growth of *Irvingia gabonensis var. gabonensis*. Aya, F., Ogogo, A., Eyo, B. (*University of Calabar, Nigeria; ayafelix@yahoo.co.uk; auogogo@yahoo.com; jeyo56@yahoo.com*).

A 16-week experiment using four watering treatments was conducted to assess the effect of watering regimes on germination and early seedling growth of *Irvingia gabonensis var.gabonensis* in a greenhouse at the University of Calabar, Nigeria. Each watering regime was divided into two 0.9-litre applications given in the morning and evening. Treatment One (T_1) consisted of a daily watering regime of 1.8 litres (12.6 litres/week); Treatment Two (T_2) consisted of watering two days/week with 3.6 litres; Treatment Three (T_3) was one day/week with 1.8 litres; and Treatment Four (T_4) was zero watering, i.e., no watering at all, and served as the control. Computing total water amounts for the experiment revealed that each seedling per polypot/bag 16 weeks after sowing utilized: 201.6 litres (T_1); 57.6 litres (T_2); 28.8 litres (T_3); and zero (T_4). Germination percentage for each treatment was 46.9%, 62.5%, 78.1%, and 62.5% for T1, T2, T3, and T4 respectively, rating best performance as $T_3>T_2$, $T_4>T_1$. Other growth parameters including dry weights of leaves, stems, and roots were significantly different at $P<0.05$. In conclusion, *Irvingia* seedlings preferred the lower water amounts. Hence, we recommend seedlings be grown in well-drained soils, while avoiding marshy or water-logged areas.

Genetic diversity and relation of Zoysiagrasses (*Zoysia* spp.) native to South Korea. Bae, E., Lee, K., Park, Y., Kim, D., Hong, K., You, B. (*Korea Forest Research Institute, Republic of Korea; gosorock@korea.com; beldel660@forest.go.kr; ybpark@forest.go.kr; skimds@forest.go.kr; honeutal@forest.go.kr; boyoofri@forest.go.kr*).

In this study, zoysiagrasses (*Zoysia* spp.) naturally growing in South Korea were collected in order to identify their morphological and genetic characteristics. Amplified fragment length polymorphism (AFLP) markers were used to analyze the genetic diversity of native zoysiagrasses to use the results as basic data to enhance its genetic variation. As a result, K-means clustering analysis was performed using cluster part of the ratio for each group, and it resulted in five clusters. Then, Bayesian clustering analysis was conducted to obtain the probability of reassignment into the five clusters with morphological classification being a precondition, and the results showed representative species of four clusters. The average genetic similarity value was found to be 0.77, which meant that the species were closely related genetically. As such, the analysis of the morphological variation and genetic diversity of native zoysiagrasses resulted in the classification into four major groups. Three of the groups were *Zoysia japonica, Z. sinica and Z. matrella*. One of the groups was assumed to be a hybrid and/or mutant with intermediate characteristics. These results give a better understanding of the levels of genetic diversity present in native zoysiagrasses and can aid in the utilization of these materials in future breeding.

Spatial expression analysis of developing xylem specific cellulose synthase gene from *Eucalyptus tereticornis* and its molecular characterization. Balachandran, K., Dasgupta, M. (*Indian Council of Forestry Research and Education (ICFRE), India; biokarpagam@gmail.com; ghoshm@icfre.org*).

Genomics research in woody perennials mainly focuses on deciphering the genetic control of wood formation. During xylogenesis, cellulose is synthesized by multi-subunits of ellulose synthase (CesA) complexes either in primary or secondary cell wall. In the present study, the spatial expression of EtCesA1 transcript was studied in different tissues of *Eucalyptus tereticornis* including leaf, internodes, developing xylem tissue, and mature xylem tissues by qRT-PCR. A 55-fold relatively higher expression of the gene was observed in the developing xylem tissues indicating its secondary cell wall specificity. Subsequently, the complete coding domain sequence of 2 940 bp was isolated [Genbank: JX276651]. It showed 94% similarity with *Eucalyptus globulus* EglCesA1, and the translated product had a predicted size of 979 amino acids which harbored the functional domain of glycosyl transferase superfamily with eight trans-membrane (TM) helixes. Further, the expression of the EtCesA1 gene was characterized during hormone signaling by qRT-PCR and in situ hybridization. Gibberellic acid and 3-Indoleacetic acid was found to significantly up-regulate the expression of the gene while 2, 4-epibrassinolide had no significant effect on its expression. Molecular analysis of CesA genes from a woody species like *E. tereticornis* will assist in better understanding cellulose biosynthesis during xylogenesis.

Assessing variability and divergence of *Jatropha curcas* Linn. germplasm under ex-situ conditions. Baragur, D. (*Indian Council of Forestry Research and Education, India; bndsira@gmail.com*).

An evaluation of 100 genotypes of *Jatropha curcas* L. was carried out to assess variability and character association and to identify diverse genotypes with superior growth traits. Variability studies revealed that 39 accessions performed better in terms of above average values for volume index (479.41 cm^3), indicating better vigor of the plants. Genotypes IC 55380, IC 555381, IC 555379, and IC 569133 were found to be superior on the basis of plant height (100.34 cm), collar diameter (3.59 cm), number of branches (3.34) and volume index (1054.91 cm^3), respectively. Estimates of broad sense heritability ranged from 5.28 to 29.78%. Genetic advance in percent of the mean ranged between 4.24 and 32.82, with number of branches giving the lowest value and volume index giving the highest value. All the growth traits showed positive significant correlations at both genetic and phenotypic levels with volume index. Path analysis of growth traits revealed that the height (0.719) is the most pronounced trait

contributing directly to volume index followed by collar diameter (0.206) and number of branches (0.110). Diversity analysis using Mahalanobis-D2 resulted in seven clusters. Genotypes in cluster 2,3,4,5, and 6 have a combination of desirable traits and can be directly selected for further improvement.

Multipurpose trees as tools for ecosystem services deployment: a case study in Uruguay. Bennadji, Z. (*Instituto Nacional de Investigaciones Agrícolas (INIA), Uruguay; zbennadji@tb.inia.org.uy*).

This work aims to present the main results of two projects on multipurpose trees as tools for ecosystem services deployment in Uruguay. The projects were executed from 2007 to 2013. The first project included an Internet survey and two national workshops, allowing the identification of a nucleus of forest owners and producers interested in the identification and priority setting of multipurpose trees. The participatory involvement of this target nucleus allowed the identification and priority setting of a native multipurpose tree (*Prosopis affinis* Spreng) and an exotic one (*Carya illinoinensis* (Wangenh.) K. Koch). The second project was oriented to the evaluation of the potential of these two species for traditional wood uses: (i) timber, energy, nonwood forest products, and (ii) the exploration of ecosystem services. The main ecosystem services identified were soil restoration and use and conservation of forest genetic resources. A collect of germplasm from all over the country was realized for the establishment of a network of 10 provenances and progenies trials in five national forestry zones. Adaptation and productivity results data at 3 years of age show preliminary trends on seed sourcing and transfer for the two species. Effects on soil properties are under study.

Sex ratio and status number in progenies test of dioecious tree species. Cambuim, J. (*São Paulo State University (UNESP), Brazil; josecambuim@yahoo.com.br*), Aguiar, A. (*EMBRAPA, Brazil; ananda.aguiar@embrapa.br*), Zaruma, D., Moraes, M. (*São Paulo State University (UNESP), Brazil; darlin@fca.unesp.br*); *ma_apmoraes@yahoo.com.br*), Freitas, M. (*Forestry Institute of São Paulo, Brazil; miguellmfreitas@yahoo.com.br*), Moraes, M., Sebbenn, A.

The dioecious trees *Astronium fraxinifolium* and *Myracrodruon urundeuva* occur naturally in some forest fragments of savannahs in Brazil, but are threatened due to agricultural development in the region. To conserve and maintain genetic diversity of the remaining populations of these species, we need information about genetic parameters, mating system, reproductive phenology, and sex ratio. Maintaining a sex ratio of 1:1 can maximize the effective population size. Progeny of two species (*M. urundeuva* and *A. fraxinifolium)* were evaluated for the sex ratio and estimates of the status number [N_s= 4.Nm.Nf/(Nm+Nf)] in Selvíria, Brazil. The design was a randomized complete block with 28 progenies, 4 repeats, and 10 trees per plot in a 1.5 m × 3.0 m spacing. At 19 years of age, male and female trees were evaluated. The sex ratio of the two species was 4:1 (81.3% males and 18.7% females) which deviated from the expected 1:1 ratio. *M. urundeuva* presented 158 females and 685 males and *A. fraxinifolium* presented 158 females and 685 males. The estimated status numbers were 514 and 481 for *M. urundeuva* and *A. fraxinifolium*, respectively. This value is approximately 60% of the census size of each species. Comparing the results from these studies suggests that the progeny test of these species exhibits sufficient genetic variability for long term *ex situ* conservation strategies.

Effect of silvicultural intensity and spacing on crown architecture of four loblolly pine clones. Carbaugh, E., Fox, T., Yanez, M. (*Virginia Tech, USA; ecarbaug@vt.edu; trfox@vt.edu; myanez@vt.edu*).

Four loblolly pine clonal genotypes have been established in three contrasting study sites in order to determine whether they retain consistent crown architecture with their respective counterparts at each study site, as well as to assess the effect of silvicultural intensity and spacing deployment on growth and crown architecture. Two of the study sites were established in the United States, one at the Reynolds' Homestead Research Center, VA, the second at Bladen Lakes State Forest, NC, and the third in Parana, Brazil. The study consisted of a split-split-plot design with two silvicultural treatments, four clones, and three spacing deployments. Three trees from each clonal plot were selected in the intermediate spacing of 1 235 trees/ha. On each selected tree, every branch was measured and evaluated for branch height above ground, length, basal diameter, and position relative to stem. The crown architecture for each clone was quantified. Results indicate that crown architecture of individual clones remained consistent among study sites and silvicultural intensity.

Effect on chlorophyll fluorescence in seedlings of four families of *Pinus leiophylla* under drought and recovery. Castelán Muñoz, N., Campos García, H., Jiménez Casas, M., Vargas Hernández, J. (*Agricultural Sciences Graduate College, Montecillo, Mexico; nayaritzin@yahoo.com.mx; hcamposg@colpos.mx; marcosjc@colpos.mx; vargashj@colpos.mx*), López Delgado, H. (*National Institute for Agriculture, Forestry and Livestock Research, Mexico; lopez.humberto@inifap.gob.mx*).

The evaluation of the relationship between moisture regimes and plant physiology in phenological stages of development is essential for the proposal of successful reforestation alternatives in regions that suffer from water shortage or where water shortage may increase due to climate change. The variation between seedlings of four families of *Pinus leiophylla* of the seed orchard at the Postgraduate College of Montecillo, Mexico, was determined. These seedlings were submitted to a cycle of drought and subsequent irrigation for recovery. The fluorescence was evaluated four times by JIP analysis parameters using PEA, and the hydric potential (Ψw) was determined with a Scholander chamber. The test seedlings maintained Ψw close to –0.4 Mpa, while the average Ψw of the seedlings exposed to drought amounted to –2.34 MPa and –3.38 MPa on days 17 and 26 of the cycle and –0.61 MPa on day 17 after recovery. Seedling of the mother from Tlalmananco, Edo Méx., showed a higher abatement of photochemical activity and very little recovery. The seedlings from the family stemming from Santa María Atepetzingo, Puebla, showed early susceptibility to the stress but a better recovery capacity. Seedlings from San Juan Tetla, Puebla, were the least affected, and those from San Rafael, Edo. Méx., had an intermediate response.

Selection of poplar clones to combat desertification in Inner Mongolia, China. Cho, W., Kang, H. (*Dongguk University, Republic of Korea; valkyre@naver.com; hdk0225@dongguk.edu*).

The objective of this study was to select poplar clones with enhanced survival rate and potential for advanced growth for combating desertification in Inner Mongolia autonomous region. After establishment of research sites in Inner Mongolia, China,

long-term monitoring results of seven domestic hybrid poplar clones from China and seven exotic hybrid poplar clones introduced from the United States and Europe are presented. Comprehensive analysis results of long-term monitoring measurement show that Hanan, Beikang, 110, DN-34 clones have a high early survival rate, height and DBH. These characteristics when continuously expressed for a long period are considered to be appropriate for poplar clones to combat the desertification in Inner Mongolia, China. Therefore, for poplar afforestation to combat desertification in Inner Mongolia, China, Hanan, Beikang, and 110 domestic hybrid poplar clones from China and the DN-34 clone which is a D×N exotic hybrid poplar clone introduced from the United States and Europe are considered to be appropriate.

454 sequencing to assess the differential expression of genes due to ozone stress in *Viburnum lantana* L. Cristofori, A., La Porta, N., Sablok, G. (*Edmund Mach Foundation, Italy; nicola.laporta@fmach.it; sablokg@gmail.com*), Pellegrini, E. (*University of Pisa, Italy; elisa.pellegrini@for.unipi.it*), Baldi, P. (*Edmund Mach Foundation, Italy; paolo.baldi@fmach.it*), Nali, C., Cristofolini, F., Gottardini, E.

Individuals of the shrub species *Viburnum lantana* L. (wayfaring tree) treated with ozone (60 ppb for 45 days for 5 hours per day) or maintained in filtered air (control) were analyzed through suppression subtractive hybridization (SSH) in order to assess the main differences of induced (I) and repressed (R) libraries, representing the response of plants at a biological, cellular, and molecular level. Biomolecular procedures consisted of: RNA extraction, PCR select (SSH), and 454 cDNA library sequencing. A total of 38 800 and 12 495 high quality reads were assembled (Newbler and CAP3 softwares) after filtering for the induced and repressed libraries, resulting in a total of 543 and 705 UniGenes, respectively. Functional annotation and gene ontology assignment were used to define the different relevance of gene ontology (GO) categories in the libraries. Results showed an enrichment of GO categories involved in the defense to oxidative stress for the induced library, with an increase in glutathione (GSH), thioredoxin-1 (Trx1), and heat shock proteins (HSP). On the contrary, the GO categories involved in carbon utilization and photosynthesis (light harvesting complexes) were repressed in ozone exposed plants of *V. Lantana*.

Evaluating the water use efficiency of selected plantation species in the Philippines. Combalicer, M. (*University of the Philippines Los Baños, Philippines; msc1330@gmail.com*), Lee, D. (*Seoul National University, Korea, Republic of; leedk@snu.ac.kr*).

Water use efficiency (WUE) is commonly used as a selection criterion to improve yield in a dry environment where water is a limiting factor. The study aimed to evaluate the WUE of different plantation and reforestation species in the Philippines. The WUE of *Acacia auriculiformis*, *Acacia mangium* and *Pterocarpus indicus* was determined from 2-year-old, 10-year-old, and 20-year-old age classes. Parameters obtained were stomata size and number, net photosynthesis (P_N), transpiration rate (E), and stomatal conductance (g_s), each of which were observed in the lower, middle, and upper portions of the forest canopy. Results showed that significant differences in P_N, g_s, and WUE were observed and were higher in 20-year-old *A. mangium* and *A. auriculiformis*. Consequently, *Acacia auriculiformis* and *A. mangium* showed better ecophysiological attributes which are important features of species for rehabilitating degraded areas of the country. These species could serve as nurse species for other native species that would eventually lead to successful forest succession in the future.

Genetic characterization of marginal pedunculate oak populations adapted to xeric conditions: implications for conservation and sustainable management. Curtu, A., Sofletea, N. (*University of Transilvania, Romania; lucian.curtu@unitbv.ro; nic.sofletea@unitbv.ro*), Finkeldey, R. (*Georg-August-University Göttingen, Germany; Reiner.Finkeldey@zvw.uni-goettingen.de*).

Over the last two decades, the average temperature has increased by 0.9 °C in southeastern Romania and will continue to rise under most climate change scenarios. The steppe bioclimatic region which is confined to this territory is supposed to enlarge, and the pedunculate oak (*Quercus robur*) populations situated at its margins will be exposed to drier environmental conditions. Here we address the question of genetic differentiation between marginal populations of pedunculate oak (known as *Q. pedunculiflora* and situated in the vicinity of the steppe), and core populations of pedunculate oak. Even though the two groups of populations can be distinguished in terms of pubescence on the abaxial leaf surface, little is known about the genetic differences between them. We sampled three pairs of populations along southeastern Romania and tested both genomic and EST-SSR markers. We found strong support for two genetic clusters that correspond to marginal and core populations, respectively. Based on our set of microsatellite markers, we are now able to characterize *Q. pedunculiflora* populations to determine the degree of admixture and to test the purity of seed lots. Our results suggested that genetics can have a significant impact on conservation of oak resources and their sustainable management.

Promoting heartwood formation of young trees of *Santalum album* by plant growth regulators. Daping, X. (*Chinese Academy of Forestry, China; gzfsrd@163.com*).

Sandalwood (*Santalum album*), one of the most valuable tree species cultivated in large areas in southern China in recently years, is renowned for its aromatic heartwood which contains fragrant essential oil. Generally, sandalwood takes from 10~13 years or longer to form fragrant heartwood. Therefore, accelerating heartwood formation in young sandalwood is one of the most urgent issues in sandalwood plantations. In this paper, we evaluated the influences of five plant growth regulators (PGRs), including abscisic acid, benzyladenine, ethrel, jasmonic acid, and methyl viologen, on growth, heartwood formation, as well as essential oil composition of 6-year-old sandalwood through a stem injection method. The results indicated that all the above PGRs treatments can induce young sandalwood to form aromatic heartwood, but no significant differences were found in height and DBH growth, but obvious different were observed in oil content and quality. Stem injection of 0.6% benzyladenine got the highest oil content in the induced heartwood among all the treatments (9.34% in average), while treatment with 0.15% methyl viologen got the least oil content (2.54% in average). Oil quality induced by benzyladenine was higher than the ISO standard for *S. album* oil regardless of the injection concentration and dosage. That may imply that benzyladenine plays an important role in the induction of heartwood formation in sandalwood.

Management of Cedar (*Cedrela odorata* L.) by means of in vitro propagation techniques. Delgado Mendez, M., Beltrán, Y. (*Instituto de Investigaciones Agroforestales (INAF), Cuba; ccforestal.leicet@ciget.camaguey.cu; beltran@yahoo.es*), Daquinta, M., Aragón, C. (*Universidad de Ciego de Ávila, Cuba; daquinta@bioplantas.cu; eduardo@bioplantas.cu*), García, R. (*Universidad Católica del Maule, Chile; rgarciag@ucm.cl*).

Cedar (Cedrela odorata L.) is one of the most important timber species for the Cuban forest sector. However, there are problems related to intensive exploitation of their natural forests. *In vitro* culture techniques applied in mature trees that can express characteristics of interest are effective at reducing the period of time necessary to obtain improved base plantations. The replication of mature trees is difficult, but it can be achieved with the use of factors to rejuvenate the vegetative material. In this work, four solutions of growth regulators were tested for shoot development in cedar cuttings. The shoot development indicators in cuttings and growth (dry mass and fresh mass) as well as biochemical indicators (content of chlorophylls pigments, enzymatic activity of the enzymes guayacol-peroxidasa and fenoles content) in the shoots were evaluated. These indicators were of great utility for the selection of *solution I* (H_2O + 6-BAP 5 mg/L) as the most suitable for rejuvenating the vegetative material and the shoots induced with this solution they were introduced to the *in vitro* culture. The results constitute fundamental premises for the later establishment of a methodology of efficient micropropagation starting with mature trees in this specie.

Isolation, characterization, and expression profiling of two homeodomain-leucine zipper transcription factor genes in *Eucalyptus tereticornis*. Dharanishanthi, V., Dasgupta, M. (*Institute of Forest Genetics and Tree Breeding, India; vdharanishanthi@gmail.com; modhumitaghosh@hotmail.com*).

Recent genome-centric approaches provide new insight into transcriptional regulation of secondary growth in vascular plants. Homeodomain- leucine zipper (HD-Zip) is one of the plant-specific transcription factors known to play a key role in organ development, meristem maintenance, plant hormone signaling, and photomorphogenesis. In the present study, we reported the isolation of two HD-Zip transcription factor genes (*EtHB1* and *EtHB2*) from *Eucalyptus tereticornis.* The full length gene of *EtHB1* was 1 223 bp in length, encompassing three exons and two introns with coding domain sequence (CDS) size of 759 bp. The translated product harbored the homeodomain and leucine zipper conserved domains. The *EtHB2* was 6 181 bp in length with 18 exons and 17 introns. The complete CDS was 2 535 bp in length and harbored the signature domains of HD-Zip transcription factor including homeodomain, leucine zipper, START, and MEKHLA. Expression profiling of both genes in leaf, internode, and developing xylem tissues was conducted using qRT-PCR. The analysis revealed a four-fold increase in expression of *EtHB2* in developing xylem while the expression of *EtHB1* was not significantly different across tissues. The expression of *EtHB2* in the developing xylem suggests its role during xylogenesis in woody perennials like eucalypts.

Effect of drought on physiological and growth processes of selected beech and spruce provenances in Central Europe. Ditmarová, Ľ., Jamnická, G., Pšidová, E., Majerová, J. (*Slovak Academy of Sciences, Slovakia; ditmarova@sav.savzv.sk; jamnicka@sav.savzv.sk; psidova@sav.savzv.sk majerova@sav.savzv.sk*), Kurjak, D. (*Technical University in Zvolen, Slovakia; kurjak@tuzvo.sk*), Ježík, M., Blaženec, M.

Growth and distribution of beech (*Fagus sylvatica* L.) and spruce (*Picea abies* Karst. L) in Central Europe are considerably influenced by water availability. The current climate change is associated with more frequent drought periods, resulting in a reduction in the tolerance of trees to other adverse environmental conditions. The objective of the study was to evaluate primary responses of selected beech and spruce provenances to water deficit with the intention of identifying material with good growth and adaptation abilities under drought conditions. We focused on changes associated with drought response, primarily in basic parameters of photosynthesis, metabolism, parameters connected with effectiveness of water use efficiency, and in growth processes. The results indicated that the provenances that originated from the optimum beech and spruce territory were manifested in general as the most viable under perfect conditions. However, under water stress, these provenance manifested major changes at both the biochemical and photochemical levels. In contrast, the highest resistance against drought stress was recorded in the provenances originating from low situated localities with a dry climate. Findings on the properties of ecotypes with lower sensitivity to drought should be used in the selection of species tolerant to drought and in forest management and reforestation-related activities.

Lateral root and shoot formation in *Rhizophora styloza* Griff. (Rhizophoraceae) geared towards effective mangrove conservation and management in the Philippines. Endonela, L., Pampolina, N., Dionisio-Sese, M. (*University of the Philippines Los Banos, Philippines; e_endonela@yahoo.com; nelsonmanguiatpampolina@yahoo.com; mldsese@yahoo.com*).

Root and shoot development in mature *Rhizophora stylosa* hypocotyls were assessed under screenhouse conditions to understand broadly its reproductive biology. The experiment was set up such that 30% of hypocotyls length was submerged in the following conditions: distilled water (control); Hoagland's solution (half- and full-strength)); and granulated complete fertilizer solution (3 g/L and 5 g/L). The experiment was maintained under full sunlight and in shaded conditions. Shoot and root parameters were measured at 5-day intervals after treatment. True leaf emergence was observed 30 days after lateral root elongation in all treatments. Although numerous root initials were observed on the submerged hypocotyl portion, lateral root formation was concentrated within 3 cm from the hypocotyl tip. Tertiary roots, however, were formed on older roots. Lateral root formation, elongation, and shoot development were more pronounced on hypocotyls subjected to half-strength Hoagland solution and 3 g/L granulated complete fertilizer solution kept under shaded conditions. The above observations are morphological evidence of effective community-based nursery production and conservation management of *Rhizophora* spp. For use in rehabilitating degraded mangrove forests in the Philippines.

Severity and control of foliar bacterial disease in *Eucalyptus* spp. seedlings according to the technological level in nurseries. Faria, J., Furtado, E., Silva, M., Passos, J. (*São Paulo State University (UNESP), Brazil; j.rdecarvalho@hotmail.com; elfurtado@fca.unesp.br; magaliribeiro@fca.unesp.br; jrpassos@ibb.unesp.br*).

In past years, a slow increase in bacterial diseases was observed, especially in diseases occurring on leaves. Disease severity varies among nurseries, and one of the hypotheses to explain this is that differences can be related to a nursery's technology

levels. The present study aimed to evaluate the severity of foliar bacterial disease in two clone seedlings from commercial nurseries of hybrids *Eucalyptus* spp. and to verify what the best disease control treatment was by relating it to the technology level present in each nursery. Treatments consisted of using the resistance activator acibenzolar-S-metil (Bion®) in three doses (0,064; 0,126 and 0,26 g/L1) and the fungicide/bactericide (Kasumin©) in the dose 2 m/L1. Evaluations consisted of measuring the level of foliar bacterial disease severity and utilization percentage of diseased seedlings. The highest technology nursery showed greater efficiency in controlling the disease and reducing its severity, and the most efficient treatment was the application of resistance inductors together with the bactericide. Regarding the medium technological level nursery, no treatment was able to control the foliar bacterial disease; therefore, there was greater seedlings mortality**.**

Micropropagation of ruil (*Nothofagus alessandrii*): biotechnology applied for conservation and management of a threatened species. García, R., Quiroz Bravo, K., Arencibia, A. (*Universidad Católica del Maule, Chile; rgarciag@ucm.cl; kquiroz@ucm.cl; aarencibia@ucm.cl*), Carrasco, B. (*Pontificia Universidad Católica de Chile, Chile; bcarrasco@puc.cl*), Palma, P. (*Universidad Católica del Maule, Chile; ppalmagarrido@gmail.com*), Candia, A., Cancino, P.

Nothofagus alessandrii is a native species from Chile, endemic of the Maule Region. Its distribution is restricted only to the coast of this region near the towns of Curepto, Constitucion, and Empedrado. It is considered a biological relict, as it is the oldest member of the *Nothofagus* genus in the Southern hemisphere. The current populations of this species are continuously decreasing because of the reduction of its natural habitat. The aim of this work was to develop an efficient protocol for embryo rescue and plant micropropagation by using mature seeds and field shoots. The best results were obtained when mature embryos were cultivated on MS medium supplemented with 2 mg/l GA3 during 30 days at 4 °C and a photoperiod of 16 hours light and 8 hours dark at 40 µmol/m2/s. Micropropagation was also achieved by cultivating nodal segments isolated from seasonal shoots of old trees. After disinfecting the explants, the shoots were cultivated into MS medium supplemented with 2 mg/L of 2-iP, inducing an average of four shoots per explants. Rooting was induced in vitro by cultivating the individualized plants on MS supplemented with IAA at 1 mg/L1. All the plants developed normally during the ex vitro culture.

Aspects and prospects of eucalyptus improvement in India. Ginwal, H. (*Forest Research Institute, Dehradun, India; ginwalhs@rediffmail.com*).

This paper describes the efforts and achievements of eucalyptus domestication and improvement in India over the past three decades. Average productivity from commercial eucalyptus plantations in India is around 20 to 25 m^3/ha/yr. However, in some cases farmers are able to achieve 50 to 58 m^3/ha/yr with improved planting material, making farm forestry an economically attractive land use option. About 58 species of *Eucalyptus* and their provenances have been tested in the past under provenance trials in various locations across the country. The initial results revealed that provenances of only two species, *E. camaldulensis* and *E. tereticornis,* performed well under rain fed conditions. The various trials indicated the superiority of north Queensland seedlots in northern and southern parts of the country. This suggests that *E. camaldulensis and E. tereticornis* breeding populations should primarily include selections from the best Queensland provenances. Seeds from the selected trees of the best performing provenances have been used to establish seed orchards and breeding populations. A series of inter-specific hybrids having the potential of producing three to four-fold more volume of wood than their parent species have been developed and deployed for commercial plantations. Some of these hybrids clones have reached new productivity standards for India conditions.

Genetic diversity and population structure of Himalayan Cedar (*Cedrus deodara*) in Western Himalayas determined with cpSSR markers. Ginwal, H. (*Forest Research Institute, India; ginwalhs@rediffmail.com*), Chauhan, P. (*Indian Council of Forestry Research and Education* (*ICFRE), India; priti14@rediffmail.com*).

Cedrus deodara, commonly referred to as deodar, is one of the most important temperate timber species of Western Himalayas and is considered one of the endangered conifer species in the region. Chloroplast microsatellites (cpSSR) were used to study genetic variation within and among populations and geographical structure in natural populations of *C. deodara* throughout its entire distribution range in Western Himalayas. Ten chloroplast microsatellite primer pairs showing consistent polymorphism were selected for studying the population genetic structure of 21 large populations of *C. deodara.* When alleles at each of the 10 loci were jointly analysed, 167 different haplotypes were identified among 1 050 individuals. The cpSSRs indicated that *C. deodara* appears to maintain a moderately high level of genetic diversity (mean *He* = 0.79), as observed in most coniferous species. AMOVA analysis showed that most of the variation in *C. deodara* occurs within populations and confirmed the general tendency of gymnosperms to display lower values of population differentiation than angiosperms. STRUCTURE analysis showed that nearly 77% of the populations were categorized as having admixed ancestry. The results are interpreted in context of future conservation plans for *C. deodara* in Himalayas.

Seasonal and diurnal water relations in four native shrubs, Northeastern Mexico. Gonzalez Rodriguez, H., Cantu Silva, I., Ramírez Lozano, R, Gómez Meza, M. (*Universidad Autonoma De Nuevo Leon, Mexico; humberto.gonzalezrd@uanl.edu.mx; icantu59@gmail.com; roque.ramirezlz@uanl.edu.mx; marcovgmeza@hotmail.com*).

Water deficit is one of the most limiting factors in northeastern Mexico. The aim of this study was to determine the water relations of four native shrub species and its relationship with soil water content and evaporative demand components. Water potential (WP) data was collected from January to October 2011 at predawn (pd) and midday (md) for *Amyris texana* (Rutaceae), *Bumelia celastrina* (Sapotaceae), *Cordia boissieri* (Boraginaceae), and *Leucophyllum frutescens* (Scrophulariaceae). During the wettest period, WPpd ranged from –0.40 MPa (*B. celastrina*) to –0.92 MPa (*L. frutescens*). In contrast, during the driest period it ranged from –1.86 MPa (*L. frutescens*) to –4.0 MPa (*A. texana*). Midday WP during the wettest period ranged from –1.08 MPa (*C. boissieri*) to –1.56 MPa (*A. texana*), while during the driest period ranged from –2.0 MPa (*L. frutescens*) to –4.0 MPa (*A. texana*). On a seasonal basis, WPpd and WPmd were positively correlated with soil water content and negatively with air temperature. Diurnal WP was negatively correlated with air temperature and vapor pressure deficit, whereas relative humidity showed a positive relationship. Since *B. celastrina*, *C. boissieri,* and *L. frutescens* showed high WP during water stress, these species are considered tolerant to a water shortage induced by drought.

Variation in fiber dimensions and basic density of plantation grown African mahogany from three forest ecological zones of Ghana. Govina, J., Opuni-Frimpong, E., Ebanyenle, E. (*Forestry Research Institute of Ghana, Ghana; kudjogovina@gmail.com; eofrimpon@csir-forig.org.gh; ebanyenle@csir-forig.org.gh*), Darkwa, N. (*Kwame Nkrumah University of Science and Technology, Ghana; nicdarkwa@yahoo.com*), Oteng-Amoako, A. (*Forestry Research Institute of Ghana, Ghana; oamaoko2002@yahoo.com*).

Ten-year *Khaya grandifoliola* C. CD. wood from three tropical forest ecological zones of Ghana (DSD, MSD, and ME) was investigated to establish variation, if any, in fiber dimension and basic density. Three trees were randomly selected from each ecological zone, and wood specimens were collected from sapwood and heartwood regions at 2%, 50%, and 95% of stem height. The mean values of fiber length (FL) in mm were 1.10±0.10, 1.23±0.03, and 1.12±0.06; fiber diameter (FD) in µm were 21.75±0.71, 20.66±0.76, and 20.96±0.40; fiber lumen diameter (FLD) were 13.57±1.16, 12.00±0.64, and 12.15±0.22; double wall thicknesses (DWT) were 8.18±0.55, 8.64±0.28, and 8.81±0.23 while the mean values in g/cm³ were 0.71±0.01, 0.71±0.01, and 0.72±0.02 for dry semi-deciduous, moist semi-deciduous, and moist evergreen zones, respectively. FL and DWT increased as precipitation increased across DSD, MSD, and ME zones. FD and FLD decreased from DSD to MSD zone but increased from MSD to ME zone. ANOVA used for mean separation on fiber dimensions were significant ($p<0.05$). The study results were comparable with naturally grown African mahogany wood, implying that *Khaya grandifoliola* plantation wood may exhibit a quality similar to natural wood.

The influence of drought on the density of different softwood species and provenances grown in eastern Austria. Grabner, M., Karanitsch-Ackerl, S. (*University of Natural Resources and Life Sciences, Austria; michael.grabner@boku.ac.at; sandra.karanitsch@boku.ac.at*), Schueler, S. (*Federal Research Centre for Forests, Austria; silvio.schueler@bfw.gv.at*), Klumpp, R. (*University of Natural Resources and Life Sciences, Austria; raphael.klumpp@boku.ac.at*).

In lowland forests with high temperatures and limited precipitation, the occurrence of drought is a limiting factor for tree growth. Soil conditions and precipitation influence the availability of water for the trees. Due to global warming, temperature-induced droughts are becoming a serious problem. The eastern part of Austria is characterized by low precipitation and high temperatures in summer. Different broad leaf tree species as well as conifers are growing in this area. Softwood species are of high economic importance here, but are also most affected by drought periods. In this study, the analysis of the density profiles (x-ray densitometry) from provenance trials of Norway spruce, different dine species, European and hybrid larch and different fir species revealed interesting differences in the density level itself as well as in the reaction of the trees to drought. During the drought periods, the mean ring density increased due to higher latewood percentage. However, an increase in earlywood density during these periods was obvious, too. First analyses showed differences in the reaction during drought of trees from different provenances, suggesting the potential to select best fit provenances according to drought resistance.

Long night treatment for induction of cold hardiness using artificial lights: effects of photoperiod on seedling storability and energy consumption. Hernandez Velasco, M., Mattsson, A. (*Dalarna University, Sweden; mhv@du.se; amn@du.se*).

Human-assisted forest regeneration in Nordic climates is considerably limited by the harsh outdoor conditions. There is only a small open window of time during the summer when the weather is favorable for transplantation and establishment of pre-cultivated seedlings in open land. Greenhouses and modern growth chambers help to cope with this limitation by allowing year-round seedling cultivation. Nonetheless, production levels are constrained to the cold storage capacity during the nontransplanting season. This storage is in turn dependent on the ability of the conifer to adapt to freezing temperatures and withstand the overall stress associated with cold hardening. Long night treatments can induce dormancy with cessation of growth and terminal buds initiation, leading to a better cold resistance. When growing forest regeneration materials under artificial lights, the lengths of the long night treatment and the photoperiod will have a significant impact not only on the biological response of the seedlings but also on the energy consumption, and thus on the CO_2 emissions. The aim of this work was to explore different long night treatment regimes for induction of cold hardiness in *Picea abies* and *Pinus sylvestris* seedlings using artificial lights. This was done with the purpose of studying the relationship between the energy consumption and the biological responses.

Cryopreservation of teak (*Tectona grandis* L.f) seeds. Hine, A. (*Universidad Nacional, Costa Rica; ana.hine.gomez@una.cr*), Abdelnour, A., Vargas, P. (*Instituto Tecnológico de Costa Rica, Costa Rica; aabdelnour@itcr.ac.cr; mpvargas@yahoo.com*).

Teak (*Tectona grandis* L.f) is a tropical tree of commercial value due to the high demand of its high quality wood and rapid growth. Genetic improvement programs for this species have resulted in seeds of better quality, and at the same time, improvement in the quality of plantations. To preserve genetic diversity and guarantee the raw material for improvement programs and for future reproduction, seeds are kept under conventional seed banks conditions with temperature ranging between 4 to –20 °C. However, there are other means to conserve this valuable germplasm. Cryopreservation is the storage of plant material in liquid nitrogen (–196 °C), and its major advantage is the conservation of material for long periods of time, under high genetic stability conditions. Survival and regeneration of plants after seed freezing in liquid nitrogen were evaluated in this work after applying the dessiccation and rapid freezing technique of cryopreservation. The methodology was tested on both seeds isolated from endocarps (seeds) and seeds inside endocarps (seeds with endocarps). Germination rates after thawing and after 28 days in culture were 84% and 70%, respectively.

Provenance study of *Cassia fistula* L. for pod, seed and seedling traits. Honnurappa, S., Nayak, R., Palaiah, S., Krishna, A. (*University of Agricultural Sciences-Dharwad, India; shivanisir59@gmail.com*); *renuka484@gmail.com; psurendra63@gmail.com; krishna.comar@gmail.com*).

Cassia fistula L., a member of the family Caesalpiniaceae commonly called Amaltas, is an important tree with many medicinal properties. Recently this species has been gaining more popularity in India for its medicinal value and wide adaptability to diverse edaphic and climatic conditions. The pods and seeds are economically important, having medicinal properties and sennoside content of commercial importance. With this point in mind, the present study was carried out in the College of

Forestry, Sirsi during 2012–2013. *Cassia fistula* L. starts flowering in the month of April to July in India, although some trees flower late in October, followed by pod setting. The average pod weight was 59.28 g, length was 57.60 cm, and the width was about 17.24 mm. The average seed length of *Cassia fistula* L. was 6.80 mm, seed width was 5.96 mm, seed weight was 16.68 g. Out of 12 different pre-sowing seed treatments, the maximum germination percentage (81.47%) was recorded in cold water soaking for 24 h followed by a dipping in concentrated H_2SO_4 for 1 min. The quality indexes including mean daily germination, peak value, germination value, germination rate of seeding were also high. Significantly increased seedling growth attributes were observed in the hilly zone for seedling height (38.20 cm), collar diameter (3.74 mm), number of leaves (12.00), shoot length (40.70 cm), root length (19.00 cm), shoot fresh and dry weight (8.50 g).

Propagation of *Entada rheedii*: a threatened climber species in Bangladesh with extremely thick and hard seed coat. Hossain, M. (*Putra University, Malaysia; aktar_forestry@hotmail.com*), Dey, J., Shumi, W. (*Chittagong University, Bangladesh; Joyeta@yahoo.com; wahhida_shumi@hotmail.com*).

This study explored the propagation techniques of *Entada rheedii*, a threatened climber species of medicinal value with an extremely hard seed coat, through seed germination with various pre-sowing treatments and clonal propagation by stem cutting. Per-sowing treatments included soaking both cut (notching) and intact seeds in water for 0 h, 24 h, 48 h, or 72 h or intact seeds in 5% acetone solution for 5 min, 10 min, or 20 min and sowing in polybags. Rooting ability of stem cuttings was investigated by treating summer or autumn cuttings with 0%, 0.4%, or 0.8% IBA solution in a non-mist propagator. The fastest seed germination with highest percentages (73.3%) and better seedling growth in terms of height, collar diameter, leaf number, and total dry mass was observed in cut seeds soaked in water for 48 h (TC2) followed by cut seeds soaked in water for 72 h (TC3), and the slowest germination with lowest percentage (3.3%) and growth performance was in intact seeds without any treatment (TU0). The highest rooting percentage with maximum number of roots (36.6) was obtained from the summer cuttings treated with 0.4% IBA solution followed by autumn cuttings with 0.8% IBA, and the lowest (43.33% and 8.25 roots) was noticed in summer cuttings in the control treatment. Results can lead to better survival and growth of rooted cuttings in nursery conditions.

Effects of exogenous GA3 application on growth and fiber quality of selected varieties kenaf (*Hibiscus cannabinus* L.) plants. Hossain, M., Muniandi, S., Abdullah, M., Shukor, N.A.A. (*Putra University, Malaysia; aktar_forestry@hotmail.com; smallmammal@yahoo.com; puad@upm.edu.my*), Abdul Malek, N. (*Forest Research Institute Malaysia, Malaysia; norlia@frim.gov.my; anishukor@yahoo.com*).

Kenaf (*Hibiscus cannabinus*), a multipurpose crop is one of the potential alternatives for natural fibers of wood for biocomposite materials including pulp and paper, insulators, packing materials, security notes, and bullet proof vests. Usually, longer fiber length and higher cellulose contents are required for better quality biocomposite materials. However, the average length of kenaf fiber is 2.6 mm in bast and 1.28 in the whole plant which is below the critical length of 4 mm needed for fiber for biocomposite production. The present study investigated whether the fiber length and cellulose content (biomass) of kenaf plants of selected varieties can be increased with the exogenous application of GA_3. Various concentrations of GA_3 were sprayed on keanf plants from 5 to 18 weeks after germination, and their vegetative and reproductive growth along with the fiber morphology were assessed. Vegetative growth of plants of all varieties were significantly enhanced with the exogenous GA_3 application up to a certain concentration, but the reproductive growth of the plants was severely impaired and failed to flower even when the control plants were at fruiting stage. The fiber quality of the kenaf plants was also significantly influenced with the exogenous GA_3 application. The findings of the study will be discussed in context to their application in the biocomposite industries.

Effects of open-field experimental warming using the infrared lamp on seed germination characteristics of major coniferous species in Korea. Hwang, J., Cho, M., Yang, A. (*Korea Forest Research Institute, Republic of Korea; jhwang@forest.go.kr; ramrami0130@gmail.com*), Han, S., Son, Y. (*Korea University, Republic of Korea; cheiron@korea.ac.kr; yson@korea.ac.kr*).

The purpose of this study was to investigate the effects of experimental warming using infrared lamps on seed germination characteristics of four major coniferous species (*Pinus densiflora, Pinus koraiensis, Abies holophylla,* and *Abies koreana*) in Korea. The experimental design consisted of a control and experimentally warmed plots with three plots (1 m^2 each) for each coniferous species. The air temperature of experimentally warmed plots was increased by 3 °C compared to control plots. Seeds of four coniferous species were sowed in April 2012. Percent germination of all four coniferous species was higher in experimentally warmed plots than in control plots, but significant differences were only noted in *A. holophylla*. In addition, *P. densiflora* and *A. holophylla* showed shorter mean germination time and higher germination energy (%) in experimentally warmed plots. The germination rate (per day) was increased by experimental warming for all species except *A. koreana*. *P. koraiensis, A. holophylla,* and *A. koreana* showed lower survival rates in experimentally warmed plots, while *P. densiflora* showed no significant difference due to experimental warming. Higher temperatures due to experimental warming induced higher percent germination, germination rate, shorter germination period, and mortality. Changes in air temperature due to global warming might bring a variation in seed germination characteristics.

Effects of irrigation period on growth performances and photosynthesis of container seedlings of *Fraxinus mandshurica*. Hwang, J., Cho, M., Yang, A., Lee, S. (*Korea Forest Research Institute, Republic of Korea; jhwang@forest.go.kr; mscho@forest.go.kr; ramrami0130@gmail.com; sg12612@forest.go.kr*).

Controlling irrigation is very important for physiological characteristics, growth, and quality of container seedlings in the container nursery system. This study was conducted to investigate growth performance, photosynthesis, water use efficiency (WUE), and stomatal conductance (gs) of container seedlings of *Fraxinus mandshurica* under three different irrigation periods (1 time/1 day, 1 time/2 days, and 1 time/3 days) for the acquisition of optimal irrigation period. The growth of root collar diameter and height of *F. mandshurica* seedlings was greatest with 1 time/1 day irrigation. The total biomass and seedling quality index of seedlings were about 1.5 times higher with 1 time/1 day than with other irrigation treatments. F. *mandshurica* seedlings showed the highest photosynthetic rate (7.62 μmol $CO_2/m^2/s^1$) with 1 time/1 day. As irrigation period was elongated, gs of *F. mandshurica* seedlings decreased, while WUE increased significantly. Based on these results, container seedlings of *F. mandshurica* should be irrigated 1 time/1 day.

The effects of seed pre-treatment, media conditions for germination of *Ricinus communis* in in-vitro system. Jang, H., Lee, S., Kang, H. (*Dongguk University, Republic of Korea; jang870331@naver.com; nash7700@hanmail.net; hdk0225@dongguk.edu*).

Ricinus communis, which is commonly known as castor bean, is an important species whose oil is used for medicine and food in spite of ricin which is a toxic component. Recently it has been used commercially in the manufacture of cosmetics, plastics, and textile materials. Various kinds of research have been conducted, but recent interest is particularly focused on using castor bean as a hyperaccumulator in metal contaminated sites. However, there are few basic studies about the introduction of *ricinus* seed, leaf, and stem in *in-vitro* system for phytoremediation. The aim of this research was to investigate the best method of introducing *Ricinus* seeds in *in-vitro* system for promoting phytoremediation experiments. This study was conducted to determine the optimal conditions for seed germination and growth along with pre-treatment prior to germination. The effects of several media (MS, WPM, SH, B5, White) as well as carbon sources (sucrose, maltose, glucose) were determined.

Investigating the interception of photosynthetically active radiation (PAR) among selected deciduous trees at Prairie Pines Preserve, Lincoln, Nebraska, USA. Kalibo, H. (*University of Nebraska, USA; hwafula@yahoo.com*).

Knowledge of how plants use photosynthetically active radiation (PAR), the light in the 400- to 700-nm waveband, is fundamental for understanding vegetation growth and productivity. The amount of light transmitted through a vegetation canopy can be an indicator of how much radiation is retained by a plant for the photosynthetic process. This presentation reports on an on-going effort at Prairie Pines Preserve, Lincoln, Nebraska (USA), where PAR measurements are underway for 12 large deciduous tree species with differing leaf and canopy structures. The amount of PAR reported is calculated as a ratio of open light to the amount transmitted through each tree canopy. Initial findings show varying levels of light interception, with eastern cottonwood (*Populus deltoides*), honeylocust (*Gleditsia triacanthos*), and Siberian elm (*Ulmus pumila*) showing the highest percentage of transmission for both direct and diffuse light. Vegetation fraction across the growing season also differed from one tree type to the next, and was similarly lower among these species. All the species also display differences in how they modulate below-canopy microclimatic conditions. These findings provide potentially valuable information about how trees in their natural settings partition incoming solar radiation for the process of photosynthesis through the growing season.

Provenance variation of growth and stem-form characteristics of *Khaya senagalensis* and future improvement strategies in Sri Lanka. Kangane Mudiyanselage, B. (*Forest Conservation Department, Sri Lanka; research.badulla@yahoo.com*).

Natural provenances of *K. senagalensis* from 21 locations throughout Western Africa (Benin (2), Burkina Faso (2), Mali (10), Niger (2), and Senegal (5)) and 3 Sri Lankan seed sources were assessed for growth (tree volume) and stem-form traits (axis persistence and straightness) at 3.5 years. Axis persistence was assessed with a 6-point scale where the highest score (6) was assigned for complete persistence and the lowest score (1) for multiple stemmed trees. Trees which were branched below the first, second, third, and fourth quarters of the tree were assigned 2, 3, 4, and 5 points respectively. Straightness was assessed with a 5-point scale. There was significant variation (0.05>P) among provenances for growth and stem-form traits. No significant trend was observed between tree volume and provenance origin parameters (latitude, longitude, and altitude). The individual tree volume of the provenances ranged from 1.45 to 2.27 dm^3, axis persistence ranged from 3.5 to 4.5, and straightness ranged from 2.8 to 3.5 among provenances. Results clearly indicate that the selection of provenances and selections within provenances, along with establishment of clonal seed orchards, clonal bank will improve the log quality and the volume production of *K. senagalensis* plantations in Sri Lanka.

ABTS radical scavenging activity from fruit water extracts of selected Korean wild pear species. Kim, H., Kim, S., Song, J., Kim, M., Park, Y. (*Korea Forest Research Institute, Republic of Korea; hyeusoo@gmail.com; goldtree@korea.kr; sjh8312@forest.go.kr; spresources@forest.go.kr; ykpark@forest.go.kr*).

The genus *Pyrus*, with the common name pear, belongs to the family Rosaceae. This study was conducted to assess the ABTS radical scavenging activity of fruit extracts of five Korean wild pear species. The superior clones of four *P. pyrifolia* (Burm. fil.), four *P. ussuriensis* Max., five *P. ussuriensis* Max. var. *hakunensis* (Nakai) T. Lee, three *P. pyrifolia* (Burm. fil.) (Jeongseon), and one *P. ussuriensis Max.* var. *ovoidea Rehder* were selected according to their major characteristics. ABTS radical scavenging activity of fruit water extracts of these plants was performed using the ABTS radical cation decolorization. At the 1 000 µg/ml, *Pyrus pyrifolia* (Burm. fil.), *P. ussuriensis* Max., *P. ussuriensis* Max. var. *hakunensis* (Nakai) T. Lee, and *P. pyrifolia* (Burm. fil.) (Jeongseon) showed strong ABTS radical scavenging activity and similar BHA. Especially, *P. ussuriensis* Max. and *P. pyrifolia* (Burm. fil.) showed highest ABTS radical scavenging activity at the 500 µg/ml (92.5, 95.3, and 94.4%). On the other hand, *P. ussuriensis* Max. var. *ovoidea* Rehder showed weak antioxidant activity. In conclusion, *P. pyrifolia* (Burm. fil.) and *P. ussuriensis* Max. had the greatest potential for the development of new antioxidant functional food.

Nuclear population structure of the Austrian *Picea abies* population. Konrad, H., Geburek, T., Schueler, S. (*Federal Research Centre for Forests, Austria; heino.konrad@bfw.gv.at; thomas.geburek@bfw.gv.at; silvio.schueler@bfw.gv.at*).

Norway spruce (*Picea abies*) is the most important tree species in Austria. In this study its genetic variation and population structure was assessed to provide the basis for breeding and conservation efforts. Samples were collected during the Austrian Forest Inventory (AFI) in 2007. A representative sample of 2 773 individuals from the Austrian Norway spruce population was obtained. Six nuclear microsatellite loci were facilitated for genotyping all samples. The results of the nuclear markers show that Norway spruce harbors a high amount of neutral genetic diversity. Heterozygosity in the sample was very high and averaged almost 90%. The efficiency of pollen flow was deduced from spatial genetic structure, as significant association between genotype and geographic distance was found at a large scale. Individual based population assignment methods using spatial information revealed five as the most likely number of founding populations. Comparisons between autochthonous and managed forests show that patterns of genetic diversity–despite intense management and documentation of long-term transnational transfer of forest reproductive material–are very similar to the potential natural state. In some regions of Austria, however, strong deviance of allelic patterns gives evidence for (historic) use of allochthonous reproductive material.

Male sterilization of *Cryptomeria japonica* by the barnase/barstar system. Kurita, M., Konagaya, K., Tsubomura, M, Hirao, T. (*Forestry and Forest Products Research Institute, Japan; mkuri@affrc.go.jp; konagaya@affrc.go.jp; mtsubo@affrc.go.jp; hiratomo@affrc.go.jp*), Watanabe, A. (*Kyushu University, Japan; nabeatsu@agr.kyushu-u.ac.jp*), Taniguchi, T. (*Forestry and Forest Products Research Institute, Japan; toru.t@affrc.go.jp*).

Cryptomeria japonica D. Don (sugi) is one of the most important commercial coniferous tree species in Japan. Enabling the rapid induction of favorable traits through genetic modification would be a powerful tool to shorten the time the traditional breeding methods have required for improving trees. However, some apprehension exists regarding the possibility of gene flow from transgenic trees to their wild relatives in the field. To address this issue, we attempted to develop male-sterile transgenic *C. japonica* to reduce the likelihood of unwanted genetic transfer by pollen. First, we constructed male sterilization vectors consisting of a male strobilus-dominant promoter and the barnase (*RNase* from *Bacillus amyloliquefaciens*) gene. The male strobilus-specific genes were isolated from a male strobilus-specific suppression subtractive hybridization (SSH) library, and the promoter sequences were isolated by the TAIL-PCR method. Male strobilus-dominant promoter::barnase fusions ligated to a nopaline synthase (*NOS*) promoter-driven barstar (barnase inhibitor) gene were introduced into *C. japonica*. After gibberellic acid treatment, all transgenic *C. japonica* formed male strobili. However, none of the *C. japonica* transformants harboring CjMALE1:: barnase-NOS::*barstar* produced pollen. Furthermore, the growth rates of transformants were comparable to those of early growth-stage wild type trees in early growth stage.

The assessment of *Populus* spp. and *Ulmus pumila* for combating desertification in Mongolia. Kwak, M., Woo, S. (*University of Seoul, Korea, Republic of; 016na8349@hanmail.net; wsy@uos.ac.kr*), Kang, H. (*Dongguk University, Republic of Korea; hdk0225@dongguk.edu*), Lee, S. (*University of Seoul, Republic of Korea; earlymay1004@yahoo.com*), Lee, S. (*Korea National Arboretum, Republic of Korea; i820316@dongguk.edu*).

Seventy percent (128 million hectares) of the grassland ecosystem in the Mongolian territory has been affected by desertification. Reforestation has become an important practice as a way of combating desertification. The objective of the present experiment was to evaluate the vitality for both *Populus* spp. and *Ulmus pumila* planted as combating means in desertification in Lun Soum (steppe ecosystem) and Tujiin Nars (forest ecosystem) of Mongolia. The visualization of differences in surface temperature by the thermal imaging camera was used to assess the transpiration rate and stomatal activity. Seedlings were planted in a flat field with and without furrows in 2008, 2009, and 2010, respectively. Most of air temperatures were higher than leaf temperatures (excepting *Ulmus pumila* planted in a flat land without furrows in Lun Soum, Mongolia). The leaf temperature of *Populus* spp. in the field with furrows was lower than those without furrows. This present study provides direct evidence that *Populus* spp. shows a positive growth in planting with furrows rather than without furrows in arid land, and *Ulmus pumila* especially displays an enhanced vitality in planting with furrows.

Discovery of genic microsatellite markers from transcriptome sequences of *Eurycoma longifolia* root. Lee, C., Abdul Malek, N., Tnah, L., Lee, S., Ng, C., Ng, K., Hasnida, H. (*Forest Research Institute Malaysia, Malaysia; leechait@frim.gov.my; norlia@frim.gov.my; leehong@frim.gov.my; leesl@frim.gov.my; chinhong@frim.gov.my; kevin@frim.gov.my; hasnida@frim.gov.my*).

Eurycoma longifolia is a highly sought after medicinal plant in Malaysia. It belongs to the family Simaroubaceae and is locally known as Tongkat Ali. The plant extract, particularly from the root, has been used in traditional medicines for treatment of various illnesses as well as for an aphrodisiac. Due to its popularity, it has succumbed to tremendous harvesting pressure. In order to ensure sustainable utilization, a conservation and management program based on baseline genetic information should be in place. For that purpose, we embarked on developing genic microsatellite markers to complement the existing 18 genomic microsatellites previously developed through enrichment approach. Based on the transcriptome sequences from a 10-year-old *E. longifolia* root generated via Illumina sequencing, a total of 48 polymorphic genic microsatellite markers were successfully developed. These markers were subsequently screened using 28 samples from Semangkok Forest Reserve. The number of alleles ranged from two to seven, whilst the observed heterozygosity ranged from 0.036 to 0.893. Significant deviation from Hardy-Weinberg equilibrium was detected in one locus (*EloT*028) after conservative Bonferroni correction. Null alleles were detected in two loci (*EloT*028 and *EloT*070). These markers can be used in DNA profiling for clonal identification, genetic diversity assessment, molecular breeding, and germplasm characterization.

Effect of soluble sodium silicate on wild *Panax ginseng* growth in red soil in Korea. Lee, S. (*Dongguk University, Republic of Korea; ssora4rang@nate.com*).

Korean Wild ginseng (*Panax ginseng* C.A. Mayer: Araliaceae) is a medicinal forest plant of great pharmacological and commercial value cultivated in Korea and elsewhere. The addition of sodium silicate to soils increases water use efficiency in cultivated plants such as ginseng and improves their tolerance to cold weather and high altitude environments. Two experiments were carried out to examine the effects of soluble sodium silicate on ginseng germination and growth. In the first experiment, seeds sown in field plots were treated at two-week intervals with 500 ppm, 1 000 ppm, 2 000 ppm concentrations of soluble sodium silicate and 500 ppm, 1 000 ppm concentrations of EM (effective micro-organisms). In the second experiment, somatic embryos produced from cotyledon segments of ginseng were cultured on MS and White media with soluble sodium silicate. The results of the field experiment showed that plant dry and fresh weight, leaf length, and root diameter were greatest in the 1 000 ppm soluble sodium silicate treatment, which also favored high photosynthesis rates and leaf chlorophyll content. The number of roots and plant height were not significant different among treatments. In the second experiment, ginseng germination and growth was better in White media mixed with a 1 000 ppm concentration of soluble sodium silicate than in MS.

The eco-physiological responses of *Quercus variabilis* seedlings to increased atmospheric CO_2 and N supply. Lei, J., Xiao, W. (*Chinese Academy of Forestry, China; leijingpin@hotmail.com; xiaowef@caf.ac.cn*).

The effects of CO_2 enhancement, nitrogen (N) deposition, and their interaction on *Quercus variabilis* seedlings were studied in Wuhan City, using a FACE (Free Air CO_2 Enrichment) facility in 2013. The treatments were elevated (EC: 700 μmol/mol) and ambient CO_2 (AC: 400 μmol/mol), and 0 kg (CK) and 120 kg N/hm^2/year (AC). The results showed that the *Quercus variabilis*

seedlings' leaf size, photosynthetic pigments and leaf nitrogen content tended to decrease under elevated CO_2, as well as the dark respiration rate decreased by 63.3% and the soluble sugar concentration increased by 2.6% compared AC plants. Nitrogen deposition significantly increased the leaf size, photosynthetic pigments, and leaf nitrogen content, but leaf potassium content decreased, and nitrogen to potassium ratio increased by 26.7%. CO_2 and N interacted to affect leaf size and photosynthesis. Plants treated with CO_2 and N had higher maximum net photosynthetic rate 8.92 μmol $CO_2/m^2/s$ (1.4 times) and light saturation point 7.43 μmol/s (2.6 times), but lower dark respiration (–65.9%) and light compensation point (–50.0%) than CK plants. Elevated CO_2 and Nitrogen deposition had positive effects on *Q. variabilis* seedlings in some degree, and their interaction promoted most.

Preliminary study of root penetration on degradable bioplastic-based planting pots. Liew, K., Khor, L. (*Sabah University of Malaysia, Malaysia; liewkc@ums.edu.my; lkim89@hotmail.com*).

Nowadays, the industry is searching for alternatives to reduce the usage of petroleum-based nondegradable conventional seedlings plant pots commonly called the polybag. In this study, three different types of bioplastic planting pots incorporated with newspaper pulp fibers were produced. The pots included different amounts of bioplastic (B) to newspaper pulp fibers (N) in the following ratios: B75%:N25%, B50%:N50%, and B25%:N75%. B0%:N100% acted as the Control. The bioplastic materials used in making the pots were made from a heat-blended mixture of starch, glycerol, vinegar, and water. All cylinder square shape molded pots with 100 mm height and 2 mm thickness were planted with *Leucaena leucocephala* seedlings for 60 days at two ground levels (below ground and above ground). Root penetrations for bioplastic pots were evaluated at an interval of 15, 30, 45, and 60 days. Results showed that bioplastic pots with a lower percentage of bioplastic (Control, B25%:N75%, and B50%:N50%) had higher root penetrations. The pots of B50%:N50% had the highest root penetration where 10% of the tested bioplastic pots had six root penetrations.

Variation of stem growth and morphology traits of some pine hybrids in southern China and their correlations. Luan, Q., Jiang, J. (*Chinese Academy of Forestry, China; luanqifu@hotmail.com; exotic-pine@hotmail.com*).

Variations in the stem growth and morphological traits of several pine hybrids in southern China were studied. The hybrids included *P. elliottii* Engelman var. *elliottii* (PEE) × *P. caribaea* var. *hondurensis* (PCH), PEE × *P. caribaea* var. *caribaea* (PCC), PEE × *P. caribaea* var. *Bahamensis* (PCB), *P. taeda* L. (PTA) × PCH, PTA × PCC, and PTA × PCB. All hybrids were tested with a randomized complete block design with five replicates of a single tree row plot planted in the field in the hilly area of the mid-north subtropical zone of China. Tree stem height (H), diameter at 1.3 m height (DBH), stem straightness (SF), branch size (BZ), branch layer number (BLN), and branch angle (BA) of the pine crosses at the age of 5 years were measured. At the same time, needle length (NL) and fascicle sheath length (FSL) of the hybrids and their parents were measured. The results of variance analysis showed that the stem growth and morphology traits of six pine hybrids have abundant diversity among different pine taxon, families, and individuals. The coefficient of variance for stem volume and straightness was 30–50% and 2–30% for other growth and morphology traits. Some of the variances have the potential to be used in the selection of pine varieties with high yield with good stem form and tolerance to the bad weather.

Genome-wide effects of selective breeding on adaptation of reforestation seedlots for future climates. MacLachlan, I., Tuytel, J., Smets, P., Wang, T. (*University of British Columbia, Canada; ianrmaclachlan@gmail.com; jtuytel@telus.net; pia.smets@ubc.ca; tongli.wang@ubc.ca*), Hamann, A. (*University of Alberta, Canada; andreas.hamann@ualberta.ca*), Aitken, S. (*University of British Columbia, Canada; Sally.Aitken@ubc.ca*).

Climatic change is predicted to cause a lag in the productivity of western Canada's forests that will have negative economic, ecological, and social impacts. We are evaluating how selective breeding affects the adaptive genetic diversity and the phenotypic and genomic architecture of reforestation seedlots in lodgepole pine (*Pinus contorta* var. *latifolia*) and interior spruce (*Picea glauca, P. engelmannii*, and their natural hybrids). Seedlots have been sampled across British Columbia (BC) and Alberta to obtain representative natural (>250 seedlots per species) and selectively bred reforestation seedlots (~20 orchard lots per species). Seedling common gardens have been established for both species in Vancouver, BC and at a field site in the central interior of BC. Phenotypic data has been collected on climate-related traits including bud phenology, cold hardiness, and growth. All trees are being genotyped for ~ 50 000 candidate adaptive SNPs selected through exome capture, re-sequencing, and subsequent analyses of associations with climate and phenotypic traits, as well as outlier tests within the broader AdapTree Project. This research will allow evaluation of reforestation seedlot diversity standards in western Canada based on adaptive rather than neutral genetic variation, and will contribute to developing climate-based seed transfer recommendations.

Nocturnal isoprene emission from deciduous trees in Japan. Miyama, T. (*Department of Meteorological Environment, Japan; tmiyama@affrc.go.jp*), Kominami, Y. (*Forestry and forest products Research Institute, Japan; kominy@ffpri.affrc.go.jp*), Okumura, M. (*Kyoto University Graduate School of Agriculture, Japan; okumura.motonori.2m@kyoto-u.ac.jp*).

Establishing accurate inventories and estimating net carbon budgets, including biogenic volatile organic compounds (BVOC), necessitates detailed evaluation of BVOC emission. Emissions of isoprene, the most abundant BVOC, presumably contribute to atmospheric chemistry through the formation of photochemical oxidants and secondary organic aerosols. We used proton-transfer-reaction mass spectrometry (PTR-MS) and an automated closed chamber to measure isoprene emissions from deciduous trees in a warm-temperate forests. In continuous foliage chamber measurements, we observed daily variations of isoprene emissions and continuous nocturnal emissions from leaves. The nocturnal emissions from trees may not be negligible.

The effects of CO_2 transfer via sap flow and bark conductance on stem respiration. Naramoto, M., Fujiwara, S., Kageyama, H., Mizunaga, H. (*Shizuoka University, Japan; amnaram@ipc.shizuoka.ac.jp; t0016036@ipc.shizuoka.ac.jp; t0916011@ipc.shizuoka.ac.jp; ahmizun@ipc.shizuoka.ac.jp*).

Stem respiration, which represents the CO_2 efflux from tree stem surface, is one of the key components concerning the carbon cycle of forest ecosystems. However, stem CO_2 efflux is not only determined by the CO_2 generated from local respiring cells, but

also is affected by xylem sap CO_2 concentration, which is influenced by the transported dissolved CO_2 via sap flow as well as the diffusion resistance of CO_2 from xylem to ambient atmosphere. In order to evaluate the effect of transported CO_2 from lower parts of the stem via sap flow, we measured responses of stem respiration rate by blocking CO_2 releases from the lower stem in a sapling of *Quercus glauca*. Stem respiration rates increased with the blocking of CO_2 released at the lower stem. This result indicated the xylem sap CO_2 concentration in the upper stem increased by blocking CO_2 released at the lower stem. In addition, we compared the bark conductance of CO_2 between different species grown in warm-temperate and temperate forests in Japan, by measuring stem respiration rates during night time when sap flow is absent.

Predicting storage life and viability of *Melia volkensii* seeds after extraction. Ndung'u, S., Angaine, P. (*Kenya Forestry Research Institute, Kenya; stephenmn06@gmail.com; pangaine2002@yahoo.com*).

Melia volkensii is a popular indigenous agroforestry tree species in arid and semiarid lands (ASALS) of Kenya. It is fast growing, tolerant to dry conditions, and is compatible with most crops, though management through root and crown pruning are recommended to minimize competition. *Melia volkensii* fruit is bulky, and even after extraction, the number of stony endocarp in a kg is around 200 stones, and therefore storage and distribution of bulky seeds is expensive as they occupy a large space. S simulation formula was used to predict the storage life and loss of viability with storage of extracted seeds by using the data collected after testing seed viability by germinating *Melia volkensii* seeds stored at different temperatures. The results showed that there was a significant difference in viability between seeds stored for different periods and at various storage temperatures (ANOVA, $p<0.05$). The results also confirmed that the formula can be used to calculate the seed viability at different times during the storage life and to estimate the period that the seed can remain viable under different storage temperatures.

Eucalyptus in Orinoco, Colombia: challenges and opportunities. Nieto, V., Barrios, A., Lopez, A. (*Corporación Nacional de Investigación y Fomento Forestal (CONIF), Colombia; victornieto@conif.org.co; alonsobarrios@conif.org.co; anamilenalopez@conif.org.co*), Borralho, N. (*Private Consultant, Portugal; nunoborralho@sapo.pt*).

Colombia has large reforestation plans across the country, hoping to reach the goal of one million hectares in the coming years. One of the regions with the greatest development potential for plantation establishment is the Orinoco of Colombia, an area with an estimated potential of about 4 million hectares suitable for afforestation. Within the range of usable species, the eucalyptus stands out as a genus with wide possibilities of use. *Eucalyptus pellita, E. tereticornis, E. camaldulensis, E. urophylla, E. grandis,* and some hybrids are among the most likely species with a high potential of success in the area. A series of plots for genetic and silvicultural monitoring have been established on which the growth and adaptation of these species is being tracked. A conclusion on the possibilities of products, processing, and markets for eucalyptus in the region based on the results and data for the studied species has been reached, and a suitable plan of action for genetic improvement is being developed.

Seedling emergence and growth of African locust bean (*Parkia biglobosa* R. Br. ex (G. Don) under different light conditions. Olayode, O., Olatunji, A. (*Ekiti State University, Nigeria; funkefaboy@yahoo.com; bamiolat@yahoo.com*).

Light as a climatic factor is vital for plant growth and determines where different species are found. Seedling emergence and growth of *Parkia biglobosa* under different light conditions were investigated to determine its suitability in other ecosystems apart from savanna where it is popularly found. Composited seeds of *Parkia biglobosa* collected from their area of natural range in Ekiti State, Nigeria were sown under the following three light conditions: direct light (DL), medium light (ML), and low light (LL). Daily germination count was done till no further germination occurred for about a week. Uniformly growing seedlings under the light conditions were assessed fortnightly for some variables. Highest germination rate of 77% was recorded under LL while the lowest rate of 58% was obtained in ML. Analysis of variance showed significant differences in the assessed variables with mean values for seedling height showing significant difference at 10, 14, 18, and 20 weeks. Also, seedling collar diameter revealed significant difference at 10, 12, 14, 16, and 18 weeks while number of branchlets showed significant difference at 10, 12, 14, and 16 weeks. The results are discussed based on *P. biglobosa*'s suitability in other ecosystems and adoption for agri-silviculture.

Sustainable regeneration of African mahogany: the effects of potting mixtures on vegetative propagation of *Khaya ivorensis* and *Khaya grandifoliola*. Opoku, E., Nyarko-Duah, N., Opuni Frimpong, E. (*Forestry Research Institute of Ghana, Ghana; Opokuensah2414@yahoo.com; nayanyd@yahoo.com; eopunifr@mtu.edu*).

Application of vegetative propagation in producing resistant progenies as part of integrated pest management of ubiquitous pests like *Hypsipyla robusta* (Moore) could ensure the sustainable regeneration of mahogany in plantations. A suitable rooting medium that promotes rapid rooting and is easily available is key to the adoption of technologies developed for farmers. This study was conducted to assess the rooting capacity of African mahogany (*Khaya ivorensis* and *Khaya grandifoliola)* in the following rooting medias: river sand, loamy soil, and mixtures of river sand and loam (50:50 v/v). Twenty cuttings per treatment with three replicates were arranged in a completely randomized block design. Number of roots, root length, and survival rate of cuttings were collected after 10 weeks in a propagator and analyzed. The 50:50 v/v mixtures of river sand and loam recorded the highest root formation (5.92), root length (8.72 cm), and survival of cuttings (71%) for *Khaya grandifoliola. Khaya ivorensis* exhibited the highest root formation (4.16) in loamy soil, root lengths (8.58 cm) in river sand, and survival (61%) in loamy soil. Hence, a 50:50 v/v mixture of river sand and loam is best for *Khaya grandifoliola* for rapid rooting while loamy soil is suitable for numerous root formation and survival in *Khaya ivorensis.*

Impact of biochar on potting media for the rooting of *Khaya ivorensis* and *Khaya grandifoliola* leafy stem cuttings. Opuni Frimpong, E. (*Forestry Research Institute of Ghana, Ghana; eopunifr@mtu.edu*), Sarfo, Y., Abbeberese, I. (*Kwame Nkrumah University of Science and Technology, Ghana; yvonnesarfo1@yahoo.com; abebus@yahoo.com*), Tagoe, C. (*Soil Research Institute, Ghana; calystagoe@gmail.com*).

The establishment of African mahogany plantations in the tropics can offset the reduced stocks of these valuable hardwoods in their native forest. Large scale plantation establishment requires sustainable production of quality seedlings. To enhance effective

rooting, a study was conducted to look at the effects of biochar additions to rooting media on *Khaya grandifoliola* and *K. ivorensis* growth. The experiement was a completely randomized block design with mixtures of 20 v biochar added to three rooting mediums of river sand (80 v), loamy soil (80 v), and 40:40 v/v mixtures (river sand and loam), and their 100% controls. Data on callusing, root number, length, and survival rate of cuttings were collated and analyzed with ANOVA. In *Khaya grandifoliola*, the 20 v biochar with 40:40 v/v mixture (loam and river sand) influenced highest root lengths (12.84 cm) and survival (67%) of the cuttings while river sand recorded the highest number of roots (2.4). The 20 v biochar with 40:40 v/v (loam and river sand) recorded highest number of roots (1.5), root length (7.17 cm), and survival rate (58%) in *Khaya ivorensis*. The 20 v biochar with 40:40 v/v (loam and river sand) medium were influential in most of the parameters measured for the tropical hardwoods *Khaya ivorensis* and *Khaya grandifoliola,* and thus are suitable for their vegetative propagation.

Genetic variation at microsatellite markers in four North American *Quercus* species. Owusu, S. (*Michigan Technological University, USA; saowusu@mtu.edu*), Sullivan, A. (*Umea University, Sweden; arslliv@mtu.edu*), Hipp, A. (*The Morton Arboretum, USA; AHipp@mortonarb.org*), Gailing, O. (*Michigan Technological University, USA; ogailing@mtu.edu*).

Models of ecological speciation indicate that new species evolution occurs through effective reproductive isolation from strong, environmentally mediated divergent selection. Oaks have become model taxa for the study of ecological speciation due to their high tendency to hybridize while maintaining distinct species identity. Twenty-eight microsatellites were characterized in natural populations of four known hybridizing *Quercus* species: *Quercus ellipsoidalis*, *Q. coccinea*, *Q. rubra,* and *Q. velutina*. These oak species are similar morphologically, suggesting the possibility of gene flow between these species. The present study was aimed at assigning individual samples to putative species and assessing past gene flow and taxonomic relationships among the four species at the microsatellite markers. We hypothesize separation of the four species into distinct clusters but with evidence of past gene flow among species with the highest level between *Q. ellipsoidalis* and *Q. velutina*. Results based on the highly variable microsatellites showed a clustering of the *Q. ellipsoidalis* and *Q. velutina* populations with the highest proportion of genetically intermediate and introgressive forms between them and a clear separation from *Q. rubra* and *Q. coccinea*. The analysis of genetic characters will allow a better characterization of the taxonomic relationships in this taxonomically difficult group of red oak species.

Genetic diversity of *Quercus ilex* L. as a tool for retracing the dynamics of the Mediterranean forest ecosystems. Paffetti, D., Labriola, M., Giovannini, G., Salbitano, F. (*University of Florence, Italy; donatella.paffetti@unifi.it; mariaceleste.labriola@unifi.it; gianluca.giovannini@unifi.it; fabio.salbitano@unifi.it*).

Forest dynamics is strongly related to disturbances that have occurred over time. Disturbance frequency and severity affects the selective processes of populations and communities. In the case of Mediterranean forests, fire induced substantial changes in the population genetics of plant species. In the frame of the research on forest dynamics, the role of vegetative regeneration as a reaction to natural (fires) or anthropogenic (coppicing) disturbances was very poor. The research was carried out in 2011 and 2012, aiming to describe the genetic structure of *Quercus ilex* populations in coppices and to assess the relationships between vegetative regeneration and diversity in genetic structure. The assumption is that vegetative regeneration tends to slow down the genetic diversity of plant populations over time. Two permanent plots in central Italy were established in former coppice woodlands dominated by *Quercus ilex* where, at least over the last five centuries, vegetative propagation is the prevailing tree regeneration system. The spatial structure of the coppice stools was measured and leaves and buds of 30 stool-shoots sampled to perform the molecular characterization by using microsatellites techniques. The results show a medium-high complexity in the genetic pattern of *Quercus ilex* coppice shoots, pointing out the residual diversity of the system.

Genetic linkage map development in *Eucalypts* for abiotic stress tolerance. Ramasamy, Y. (*Institute of Forest Genetics and Tree Breeding, India; yasodharaja@yahoo.com*), Viswanathan, S. (*Nehru Arts and Science College, India; v.subashini85@gmail.com*).

India is the largest planter of *Eucalyptus* at about 18 m ha. It is used as the source of pulp, fuel wood and energy. *E. tereticornis* and *E. camaldulensis* are the most commonly grown species due to their adaptability to arid regions. Under the genetic improvement program for eucalypts, seed orchards and clones were developed for plantation programs. Recently, inter-specific hybrid production through controlled pollination has been practiced to harbor heterosis through clonal propagation. Simple sequence repeat (SSR) markers were identified for parentage confirmation of hybrids and quality control genotyping during propagation. A genetic linkage map was developed for the first time in the cross *E. tereticornis* x *E. camaldulensis* by selecting the high yielding clones but differing for the salinity tolerance traits using SSR markers. A total of 273 SSRs were screened for polymorphism between parents, and 139 showed clear polymorphic alleles. Using two-way pseudo-testcross strategy, 53 loci were mapped in 11 linkage groups in both the parents. The total map length for male and female parents was 1 422.28 cM and 1 845.8 cM, respectively.

Somatic embryogenesis in *Hyeronima alchorneoides* (Euphorbiaceae) from zygotic embryos. Rojas, A., Hine, A. (*Universidad Nacional de Costa Rica, Costa Rica; alejandra.rojas.vargas@una.cr; ana.hine.gomez@una.cr*).

There is an interest in developing a protocol for somatic embryogenesis in *Hyeronima alchorneoides*. This species is of particular interest because in Costa Rica it is a fast growing tree species with high ecological and economic value. Also, it presents problems with recalcitrant seed storage, and in the country it is seriously attacked by a wasp that feeds on the embryo, which greatly reduces seed production. Therefore, somatic embryogenesis was proposed as a solution to mass propagation *H. alchorneoides*. In this research, we were able to induce embryogenic callus after 60 days of culture on MS medium supplemented with 2.68 µm NAA or 9.05 µm 2,4-D combined with 1.34 µm NAA. After 120 days of culture, we were able to obtain 254 and 147 somatic embryos in the respective culture mediums. Maturation and germination conversion of somatic embryos was obtained in a culture medium free of growth regulators on light conditions. This technique and its advantages are verified with the establishment of *Hyeronima alchorneoides* somatic embryogenesis from zygotic embryos. However, like other woody species, we conclude that a lack of synchrony in the development of somatic embryos remains one of the challenges to overcome in somatic embryogenesis.

Annual climate variation shapes adaptive seedling characters: A contribution to the adaptation of trees to future climates? Schueler, S. (*Federal Research Centre for Forests, Austria; silvio.schueler@bfw.gv.at*).

The adaptability of forest trees to changing climate conditions mainly depends on two requisites: firstly, on the genetic variation of tree species, and secondly, on the epigenetic status of the responsible genes, that is whether genes are being expressed or not. We aimed at testing the effects of weather conditions during pollination, embryogenesis, and seed development on the performance of seedlings from open-pollinated seed orchards and seed stands from different provenances of the conifers *Pinus sylvestris, Picea abies*, and *Larix decidua.* Extreme environmental conditions that were found in different seed years represent the environmental trigger. In a nursery trial with a normal and a water deficit treatment, we characterized various quantitative traits (i.e., phenology, drought tolerance). Significant differences were found among the tested species, among provenances, among the precipitation treatments, and most importantly, among the years in which the seeds were produced. This suggests that the effect of interannual variation of climate during pollination and seed maturation has a larger effect on the performance of produced seeds, respectively the seedlings emerging from these seeds, than previously thought and that it contributes to the adaptations of forest trees to climate change.

Genetic diversity and breeding strategies for genetic improvement of *Melia composita* Willd. Sharma, S., Dobhal, S., Kumar, A. (*Indian Council of Forestry Research and Education (ICFRE), India; shrutiddn@gmail.com; shivanido@gmail.com; ashok@icfre.org*).

Melia composita Willd. is an important tree species for ply and pulp wood and has a great potential to be cultivated under agro and farm forestry programs. Bridging the ever increasing gap between demand and supply for such woods is possible by screening genetically diverse and productive parents and multiplying them on a commercial scale for wider deployment. Although this native to the Indian sub-continent has attracted great attention from growers and industrialists, limited research has been carried out on its genetic improvement and breeding that would allow for supplying quality planting stock. This research originated with DNA fingerprinting by optimizing DNA extraction protocols and screening molecular markers for genetic analysis so that field deployment and breeding strategies could be drawn out appropriately. The DNA was extracted from juvenile leaves by standardized extraction protocols. The quantity and quality of DNA obtained was evaluated for PCR-based analysis, and 28 ISSR primers of the University of British Columbia were screened for amplification. Different annealing temperatures were examined to optimize amplification conditions, and eventually primers producing clear, robust and reproducible bands were recommended for evaluating existing genetic diversity**.**

Wastelands rehabilitation by growing genetically improved *Melia composita* Willd. Sharma, S., Kumar, A. (*Indian Council of Forestry Research and Education (ICFRE), India; shrutiddn@gmail.com; ashok@icfre.org*).

Melia composita Willd. is an important multipurpose tree species grown commercially under various afforestation programs for fodder, timber, and industrial woods. The availability of genetically improved planting stock is almost non-existent and has become a serious challenge. Therefore, the selection and characterization of genetically divergent genotypes using breeding techniques was initiated to select 230 candidate plus trees using index method based on height, diameter at breast height, straightness, clear bole height, crown diameter, and knots. Trees with an index value of >75 (58 trees) were selected as plus trees, and the average index value of plus trees was 81.81. Genetic evaluation of the 21 most suitable progenies was carried out in six geographical locations to analyze stability and adaptability and screening of suitability of genotypes for arid and semi-arid regions. The progenies/genotypes which survive and sustain in the toughest conditions of more than 48 °C of temperature and very little rain are expected to play a crucial role in rehabilitation of arid and semi-arid zones. The program would essentially ensure development of suitable ideotypes with sustainable water use for such degraded regions and contribute substantially to carbon sequestration when deployed commercially.

Species diversity effects on productivity and water use in a tropical tree plantation. Sinacore, K., Asbjornsen, H. (*University of New Hampshire, USA; ksinacore@gmail.com; heidi.asbjornsen@unh.edu*), Hall, J. (*Smithsonian Tropical Research Institute, USA; HallJe@si.edu*), Ducey, M. (*University of New Hampshire, USA; mjducey@cisunix.unh.edu*).

High global rates of tropical deforestation are increasingly being countered by tree planting, providing a unique opportunity to restore many critical ecosystem services and functions that have diminished as a result of past land use. Although the majority of forest plantations have involved monocultures, there is growing emphasis on mixed-species systems as a means of increasing productivity and providing multiple ecosystem services. However, a possible consequence of greater productivity in mixed-species stands is greater plant moisture stress during periods of drought. We hypothesize that planting mixtures of species having complementary or facilitative interactions (e.g., root architecture, phenology, nutrient cycling capability) can enhance stand-level water use efficiency, thereby maximizing productivity and resilience to drought. Two questions we seek to answer are: (1) how do different combinations of plant traits influence stand productivity and transpiration, and (2) how is this relationship further mediated through differences in individual species and stand-level water use efficiency? Our research at the Agua Salud Project in Panama will use a combination of sap flow, photosynthetic rates, and isotope analysis techniques in monocultures, two-species, and six-species plantings to explore these questions. This paper presents preliminary results from this work and discusses implications for tree planting efforts and future research.

An association mapping approach using ISSRs and AFLPs to identify molecular markers for resin yield in *Pinus roxburghii* Sarg. Singh, A., Barthwal, S., Ginwal, H. (*Indian Council for Forestry Research and Education (ICFRE), India; anitasrawat@gmail.com; santan@icfre.org; ginwalhs@icfre.org*).

In *Pinus roxburghii*, marker-trait associations were studied for resin yield using 238 molecular markers derived from 9 ISSR and 5 AFLP primer pairs. Regression analysis identified 16 ISSR and 12 AFLP markers showing significant associations with resin yield accounting for 87.53 and 97.56 percent of the phenotypic variation respectively. To avoid false positive associations, a model-based cluster analysis implemented in the software STRUCTURE was performed which revealed the population to be stratified into five subpopulations. The grouping of genotypes into five subpopulations had no correlation with their resin yield

thereby eliminating the possibility of shared ancestry among them. Structured association test was then carried out using the software STRAT conditional on the inferred population structure. In the absence of population structure, 34 ISSR and 31 AFLP loci showed significant association out of which 2 ISSR and 6 AFLP loci were common with those identified by regression analysis. Upon considering population stratification, 51 ISSR, and 17 AFLP loci revealed association out of which one ISSR ($UBC873_{1319}$) and one AFLP locus (E_{ACA} M_{CTA51}) was found to be common with those identified by both regression analysis and structured association test assuming no population stratification showing their strong association with the trait.

Genetic evaluation of Pinus roxburghii genotypes varying in resin yield using microsatellite markers. Singh, A., Barthwal, S., Ginwal, H. (*Indian Council for Forestry Research and Education (ICFRE), India; anitasrawat@gmail.com; santan@icfre.org; ginwalhs@icfre.org*).

Pinus roxburghii genotypes collected from Tiunee (Chatra), varying in resin yield from 0.25 to 8.0 Kg/year were tested for differences in their genetic constitution using microsatellites. The hierarchial clustering using UPGMA implemented in the software DARwin 5.0.158 grouped the genotypes into two distinct clusters based on their resin yield rather than their site of collection. The dissimilarity coefficients ranged from 0.04 to 0.72 suggesting high genetic variability among the genotypes. Model based clustering identified five sub-populations in the sample. The distribution of genotypes into different subpopulations had no correlation with their resin yield showing that resin yield of the genotypes was not attributed to their ancestry but it was because of their genetic constitution. AMOVA by collection site revealed no significant variation among the groups whereas in AMOVA by resin yield, percentage of variation among the groups was 10.96% with an F_{ST} value 0.109 which was highly significant ($p < 0.001$). The F_{ST} value 0.1096 indicated that there was moderate genetic differentiation among the groups. The study suggested that the variation among the genotypes at the molecular level was correlated with the variation in resin yield and not their site of collection thus highlighting the genetic basis of the trait.

Genetic diversity and evolutionary relationship of *Dyera costulata* and *Dyera lowii* in Jambi, Indonesia based on AFLP markers. Siregar, U. (*Bogor Agricultural University, Indonesia; siregaruj@gmail.com*), Hamzah, S. (*Jambi University, Indonesia; hamzahtbr@yahoo.com*), Suharsono, U., Siregar, I. (*Bogor Agricultural University, Indonesia; ututsuharsono2002@yahoo.com; izsiregar@yahoo.com*), Finkeldey, R. (*University of Gottingen, Germany; rfinkel@gwdg.de*).

Dyera costulata and *D. lowii* are endangered indigenous tree species that grow in two different habitats in Jambi, Indonesia. *D. costulata* grows on hill areas while *D. lowii* is usually found in lowland swampy forest. Both trees are intensively harvested by the local community for their latex and wood. Although listed as two different species, the local community often uses these species interchangeably in reforestation programs in the area. This study investigated the genetic diversity of randomly sampled trees of *D. costulata* and *D. lowii* planted in the area using AFLP markers. Two primer combinations (i.e., E-ACC/M-CTA and E-AGG/M-CTC) generated AFLP bands. *D. costulata* (He=0.38) had twice the diversity of *D. lowii* (He=0.19). Dendrogram based on Nei's genetic distance separated the two species, however, some *D. costulata* acessions showed a closer association with *D. lowii*. The possibility of gradual evolutionary changes from one species to another as the habitat changed from hill area to swampy lowland is discussed.

Transition wood age from early wood to late wood of *Pinus radita* D. Don, in the Andean region of Cochabamba City, Bolivia. Sirpa Espinoza, E., Vargas, J. (*Universidad Mayor de San Simon, Bolivia; eve.sirpa@hotmail.com; j.vargas@umss.edu.bo*).

In the department of Cochabamba (Bolivia), there is a large number of forest plantations, among which the species *Pinus radiata* D. Don can be found. Currently the use of this wood has increased significantly. Noticing the lack of scientific information on this species, we wanted to determine the age of transition from early wood to late wood and assist the optimization in silvicultural interventions for industrialization. The following methodology consisted of the analysis of samples (timber core samples) from permanent forest sample plots of different ages and different places. In each sample (timber core sample), growth rings were selected and samples were extracted from the vegetable late wood to be disaggregated to obtain tracheids which were observed under the microscope and were photographed. The photographs were analyzed with SigmaScan Pro to obtain the length and diameter of the tracheids. The age of transition was found to be 19 years old, with a period of transition from early wood to late wood from 17 to 23 years old. The results of the study suggest that forest plantations of *Pinus radiata* D. Don that are 19 years old (age of transition) could provide wood that has culminated in the early wood period.

Mass propagation of Korean raisin tree through veneer grafting. Song, J., Kim, S., Kim, M., Kim, H., Park, Y. (*Korea Forest Research Institute, Republic of Korea; sjh8312@forest.go.kr; goldtree@korea.kr; spresources@forest.go.kr; hyeusoo@gmail.com; ykpark@forest.go.kr*).

Korean raisin tree (*Hovenia dulcis* var. *koreana Nakai*) is considered not only a fruit but also an herbal medicine in East Asia including Korea, Japan, and east China. As honey plant, the value of this species was rising steadily. This study was conducted to develop the propagation techniques and determine effects of scion collection time, scion age, and use of a vinyl house on survival rate of *H. dulcis* var. *koreana Nakai*. The survival rate by veneer grafting showed no significant differences among the three new cultivars. The most appropriate time for scion collection in the northern temperature zone was observed to be before the spring equinox when plants are fully dormant. The installation of a vinyl house showed above 86% of grafting survival rate. The scion age did affect survival rate with 1-year shoots having an increased grafting survival rate than 2-years shoots. In this case, the installation of vinyl house can contribute above 80%.

Conservation monitoring of *Erythrina velutina* in riparian forest area. Souza, D., Melo, M. (*São Paulo State University (UNESP); danillacristina@ig.com.br; mariliafvm@yahoo.com.br*), Gois, I. (*Viçosa Federal University, Brazil; itamarafloresta@gmail.com*), Silva-Mann, R. (*Sergipe Federal University, Brazil; renatamann@hotmail.com*).

One of the major challenges for the agricultural system is to establish agricultural production coupled with the conservation of genetic resources, mainly aiming at the preservation of permanent protection areas. In this context, the species mulungu

(*Erythrina velutina* Willd.), among other natives, has been suffering with anthropogenic pressures in various ecosystems. The objectives of this research were to (1) use ecological and genetic population parameters, including molecular markers (allozymes and ADN), as indicators of sustainability in two natural populations of mulungu in the State of Sergipe, Brazil, and (2) to evaluate the tendency sustainability of populations intended for monitoring and conservation. The matrix pressure-state-impact/effect-response (PSI/ER) along with the selection of 14 indicators (density of species, population effective size, density of seeds, tree height, diameter at breast height, polymorphic fragments of ADN, polymorphic loci, Shannon index, genetic diversity among populations, heterozygosity, gene flow, inbreeding coefficient, number of publications, and Germplasm Active Banks) can serve as a reference for monitoring forest fragments in riparian areas for their ability to maintain native species, such as mulungu, in rarity character. The populations studied showed low tendency toward sustainability.

Genetic admixing of two evergreen oaks, *Quercus acuta* and *Q. sessilifolia* (subgenus Cyclobalanopsis), is the result of frequent interspecific hybridization. Tamaki, I. (*Gifu Academy of Science and Culture, Japan; garageit@gmail.com*).

It is well known that the species boundaries of oaks are relatively weak, and hybridization is reported frequently. Our study species are *Quercus* acuta and *Q. sessilifolia* (subgenus *Cyclobalanopsis*), and the existence of their putative hybrid *Q.* x *takaoyamensis* has been known. We investigated leaf morphological traits and microsatellites of the two oaks in the area where the two species are distributed. Although, each leaf trait of the two species was duplicated, the two species could be distinguished morphologically by PCA based on all leaf traits. They were also genetically differentiated with $F_{ST} = 0.104$. However, they shared most of the alleles in all studied loci, and considerable genetic admixing was detected. Model-based testing showed that this admixing was created by not only shared ancestral polymorphism but also hybridization. The effective numbers of migrants per generation to *Q. acuta* and to *Q. sessilifolia* were 9.32 and 68.05, respectively. Theoretically, it is considered that 1–10 migrants per generation are required to prevent complete genetic differentiation. Based on the results of this and several previous studies on *Quercus* species, it appears that genetic admixing with most allele sharing is probably common in this genus and is maintained by interspecific hybridization.

Identification of *Ganoderma* species associated with *Acacia cyclops* mortality in the Western Cape region of South Africa. Tchotet Tchoumi, J., Coetzee, M., Wingfield, M. (*University of Pretoria, South Africa; michel.tchotet@fabi.up.ac.za; martin.coetzee@up.ac.za; Mike.Wingfield@up.ac.za*), Rajchenberg, M. (*Centro de Investigación y Extensión Forestal Andino Patagónico, Argentina; mrajchenberg@ciefap.org.ar*), Roux, J. (*University of Pretoria, South Africa; jolanda.roux@fabi.up.ac.za*).

Acacia cyclops is an invasive tree in the Western Cape region of South Africa, although it also has value in providing fuel wood for local communities. Approximately three decades ago, it was noted that these trees were dying in large numbers and this die-off has continued to occur. Dying trees have been shown to suffer from a rapidly developing root disease resulting in the wilting of trees and a white rot of the affected roots and bases of trees. Previous attempts to determine the cause of the disease suggested that the fungus *Pseudolagarobasidium acaciicola* was affecting the trees. However, sporocarps of a fungus resembling *Ganoderma* are also commonly associated with the roots and bases of dying trees. The aim of this study was to identify the possible *Ganoderma* species using DNA sequence analyses. Isolates were obtained from sporocarps and roots of diseased trees, and DNA sequences were generated from the ITS and mtSSU regions. Results suggested that a *Ganoderma* sp. in the *Ganoderma lucidum* complex is associated with the disease. Future studies will focus on pathogenicity trials in order to verify the role of this fungus, as compared to *P. acaciicola*, in causing the wide scale death of *A. cyclops*.

Ex situ germination behavior of stored seeds of medicinal plants from Indian Himalayas. Thapliyal, M. (*Forest Research Institute, India; manishapasbola@rediffmail.com*).

The increase in global demand for medicinal plants has increased the exploitation of their natural populations through crude and unsystematic extraction methods. The Indian Himalayan Region is rich in diversity of valuable species of known medicinal value. However, dwindling populations due to over-exploitation necessitates evolving effective propagation and conservation strategies, and seeds are the most efficient means for most species. To develop *ex situ* conservation strategies for six Himalayan medicinal plants viz. *Artemisia vulgaris, Berberis asiatica, Berginea ligulata, Hippophae salicifolia, Saussurea lappa* and *Myrica nagi*, seeds were studied for germination behavior, seed dormancy levels, and pretreatment and storage behavior using standard ISTA methods. Dormant seeds were pretreated with growth promoters like GA_3 and KNO_3. *B. asiatica* seeds responded best to GA treatment (80%) and lost viability in 6 months; *S. lappa* yielded 75% germination under GA_3 pretreatment against 40% in untreated seeds; 32% of seeds of *M. nagi* germinated in GA_3 pretreatment while untreated seeds yielded only 7% germination. *B. ligulata* seeds responded best to KNO_3 pretreatment (68%), while untreated seeds of *A. vulgaris* germinated for more than a year. The study determines the viability period of the seeds in storage conditions for regenerating the species in posterity.

Assessment of seed quality and mycoflora of *Bauhinia retusa* in different storage conditions. Thapliyal, M., Singh, Y., Kainthola, C., Bagwari, A. (*Forest Research Institute, India; manishapasbola@rediffmail.com; singhyp@icfre.org; tinni0509@gmail.com; archana.bagwari25@gmail.com*).

Bauhinia L. is a genus of shrubs and medium -sized or large trees of more than 200 species having traditional and medicinal application. In sub-tropical Himalayan belt of Uttarakhand, (India), *B. retusa* is a good source of green fodder during dry summer months. Seeds of *B. retusa* from various sources were observed for their storage behavior and for conservation of germplasm in seedbanks. Fresh seeds were tested for viability and vigor and then stored in plastic containers at ambient and low temperatures. Seed viability and seed health were assessed every 3 months, because fungi can lower the quality of seeds by causing discoloration and reducing germination. Among different causal agents, the impacts of fungi are considerable because pathogens of maturing seed reduce the yield. Mycoflora in seeds were detected by blotter method by the International Seed Testing Association. Viability of seeds declined from 90% to 24% in about 2.5 years in seeds from the Rambaar source while in the Majhera source, loss was slow from 94% to 86%. Seeds in stored condition had significantly more fungal colonies than in fresh. In stored seeds, *Aspergillius* count was highest. Periodic checks of seed health are important because a rise in fungal infection under stored condition may lead to its deterioration.

Genetic variation in natural and planted populations of *Shorea guiso* (Dipterocarpaceae) in the Philippines revealed by microsatellite DNA markers. Tinio, C. (*University of the Philippines Los Banos, Philippines; crusty.estoque@yahoo.com*), Finkeldey, R. (*Georg-August-University Göttingen, Germany; Reiner.Finkeldey@zvw.uni-goettingen.de*), Prinz, K. (*Friedrich-Schiller-University Jena, Germany; kathleen.prinz@uni-jena.de*), Fernando, E. (*University of the Philippines Los Banos, Philippines; edwino.fernando@gmail.com*).

The genetic diversity of four natural and four planted populations of *Shorea guiso* in the Philippines was investigated using microsatellite DNA markers to compare patterns of variation within and among the populations. Leaf samples were collected from trees in eight sites and three islands in the archipelago and extracted for genomic DNA. Six polymorphic microsatellite markers were used. We employed standard genetic diversity measures to quantify genetic variation. Results indicate a high level of genetic diversity within populations of *S. guiso.* The natural populations in Bohol (N_BOH) showed the highest genetic diversity among the four natural populations while Bislig (P_BIS) was highest among the planted populations. An AMOVA revealed high variation within populations (95.39%) and low variation among planted populations (4.61%). Further, an AMOVA among both population types (natural and planted) revealed no differentiation (-0.80%) among the groups, with 5.2% of variation occurring among populations within groups and 95.6% variation within populations. The largest genetic distance was found between the natural populations N_BOH/N_SUB (0.332) and the smallest was between N_MAK/P_MAK from both population types (0.041). This study proves the usefulness of microsatellite markers in the assessment of genetic variation within and among populations and determination of the origin of the planted populations.

A new approach to propogate *Spondias pinnata* without potting media. Tomar, A. (*Centre for Social Forestry and Ecorehabilitation, India; anitatomar@icfre.org*).

Growing plants without soil is not new. Man started agricultural pursuits by growing plants in soil, but as the knowledge of plant nutrition increased, he learned to grow plants in artificial media. The next step was to eliminate solid media and to grow plants directly. In the present study, an attempt was made to germinate seeds of *Spondias pinnnata* without any potting media. *Spondias pinnata* is a deciduous, glabrous tree with edible fruit, growing up to 25 m in height. Despite being a valuable and threatened plant, *S. pinnata* is not cultivated on a large scale in its native habitat. Seeds of *Spondias pinnata* were collected from sites situated between latitude 25007′ to 25010′N and longitude 81054′ to 81058′ E and at 98 m elevation. Seed germination tests involved four replications of randomly selecting 25 seeds each from the working sample. The commencement of soilless germination started on the 10th day onwards after sowing and continued up to 20 days inside the muslin cloth. The seed germination varied significantly (ANOVA; F-value = 5.46 and p = 0.02) during the study period. Total germination recorded was 96%, of which the maximum germination (64.0%) was observed in the second week of sowing.

Rhizome macroproliferation: a new technique of propagating herb and fern. Tomar, A. (*Centre for Social Forestry and Ecorehabilitation, India; anitatomar@icfre.org*), Srivastava, R. (*Tamil Nadu Forest Department, India; srivastavaraj3@yahoo.com*).

The plants at higher altitudes of the Himalayas are generally propagated by rhizomes. The propagation by rhizome and stem cuttings has emerged as an efficient method of multiplication and conservation of such species. Therefore, this present study was conducted to macro-proliferate *Gentiana kurroo,* an endangered medicinal herb, and *Cyrtomium caryotideum,* a medium sized fern, through rhizome cuttings. For the present study, growing tips of rhizome were split into two, three, and four longitudinal parts. Each split contained ½, ⅓, or ¼ of longitudinal section of the mother rhizome and aboveground part with growing buds. *G. kurroo* and *C. caryotideum* two piece rhizome exhibited significantly higher survival percentage than three and four pieces. *G. kurroo* two and three pieces IBA treated cuttings showed better results than IAA treatments. *C. caryotideum*'s two and three piece cuttings provided the best survival under controlled conditions, and four piece cuttings thrived better under 300 ppm IAA treatment. Rhizome-macroproliferation of *G. kurroo* and *C. caryotideum* is a new, simple, easy and effective technique for multiplication and conservation of these endangered herb and fern species for the production of more plants for future conservation.

Eucalypts in China: research history, present situation of breeding and silviculture and future prospect. Wu, S., Xu, J. (*Chinese Academy of Forestry, China; wushijun0128@163.com; jianmxu@163.com*).

During the past three decades, an increase in research on breeding and silviculture has improved *Eucalyptus* productivity, and to some extent our standing of their effects on tree growth and on wood properties. Unfortunately, very little information about these two procedures on the review of *Eucalyptus* grown in China has been published even though this species was introduced some 120 years ago. This paper reviews the available information regarding research history and progress of breeding and silviculture under Chinese ecological conditions and to outline some suggestions to them. According to the present research situation of breeding and silviculture, we would recommend that: generalizing empirical and useful practices; developing high-value products; creating more clones for demand; carrying out intensively research over different species and clones for different cultivation goals at different sites over time; associating quarantine, identification, control and breeding to reduce the impact of eucalypt pests and diseases; above all, applying breeding strategy, especially for multiple generations and interspecific hybrid breeding.

The effect of plus-tree selection on the genetic diversity of two *Acacia mangium* seedling seed orchards in Indonesia. Yuskianti, V. (*Center for Forest Biotechnology and Tree Improvement, Indonesia; vivi_yuskianti@yahoo.com*), Isoda, K. (*Forestry and Forest Products Research Institute, Japan; keiso@affrc.go.jp*), Nirsatmanto, A. (*Center for Forest Biotechnology and Tree Improvement, Indonesia; arif_nirz@yahoo.com*).

To know the efficiency of phenotypic selection conducted on a seed orchard, it is necessary to measure the genetic diversity of the base population and the population after selection. The genetic diversity of a base and plus-tree population of two *Acacia mangium* seed orchards in Kalimantan (AM006 Group C) and Sumatera (AM004 Group D) that had been established using Australian provenances were analyzed using 12 microsatellite markers. Both had been subjected to similar procedures of plus-tree

selection. FSTAT analysis showed that the level of genetic diversity in the base population of both orchards was comparable. For the plus-tree population there were significant increases in the level of genetic diversity in the AM004 Group D (He=0.609 for base and He=0.625 for plus-tree) but not in the AM006 Group C (He=0.607 for base and He=0.602 for plus-tree). The level of inbreeding decreased in the AM004 Group D (Fis=0.146 for base and Fis=0.094 for plus-tree) and increased in the AM006 Group C (Fis=0.118 for base and Fis=0.150 for plus-tree). Thus, selection applied for the AM004 Group D was more efficient than for the AM006 Group C. Several factors may have contributed to this difference. Management strategies that can be applied for the next selection are discussed.

Genetic diversity of natural populations of endangered *Ormosia hosiei*, endemic to China. Zhang, R., Zhou, Z. (*Chinese Academy of Forestry, China; ruirui0218@126.com; cafzzc@126.com*), Du, K. (*Agriculture University of Hebei, China; kejiudu@yahoo.com.cn*).

Ormosia hosiei is native to China and valued for its timber. In order to help preserve this endangered wild species, we investigated the distribution of *O. hosiei* populations in southern China. Based on ISSR markers, 101 clear and reproducible DNA fragments were generated. Of these, 96 (95.1%) were polymorphic. Shannon's index (I) and Nei's gene diversity (h) were 0.5483 and 0.3747, indicating a high level of genetic diversity. Moreover, there was a lack of significant association between genetic and geographical distances in the populations. The distribution of genetic diversity among the wild populations of *O. hosiei* in southern China may be the result of events in the species' evolutionary history, including habitat fragmentation and habitat damage caused by human activity. Based on these findings, we suggest that areas with larger populations of *O. hosiei* should take effective measures to ensure the conservation.

Genetic diversity and differentiation within three species of the family Lauraceae in southeast China. Zhang, R., Zhou, Z., Jin, G. (*Chinese Academy of Forestry, China; ruirui0218@126.com; cafzzc@126.com; phr2122@126.com*).

A comparative analysis was undertaken of the genetic diversity and genetic structure of three coordinal tree species from southeastern China. The species *Phoebe chekiangensis* C.B. Shang, *Phoebe bournei* (Hemsl.) Yang, and *Machilus pauhoi kanehira* are all valued for their timber. Nine populations from two provinces were screened for variability with ISSR markers. Percentage of polymorphic loci, Nei's gene diversity, and Shannon's index were lower in *P. chekiangensis* (PPL%=78.8%, h=0.2301, and I=0.3522) than in *P. bournei* (PPL%=90.3%, h=0.3223, and I=0.4776) or *M. pauhoi kanehira* (PPL%=92.0%, h=0.3714, and I=0.5412). Larger populations were found to possess greater genetic diversity. Distinct genetic differentiation was found to have taken place in *P. bournei*, and barrier analysis showed two barriers in the four populations studied. Special environments were found to influence population differentiation.

GENERAL POSTER SESSIONS

IUFRO Division 3: Forest Operations Engineering and Management

Urban forest ecosystem assessment in Louisiana, USA, using the i-Tree Eco Model. Abdollahi, K., Ning, Z. (*Southern University, USA; kamrana664@cs.com; Zhu_ning@subr.edu*).

i-Tree Eco, an adaptation of the Urban Forest Effects (UFORE) model, was used to provide urban and community forestry analysis and benefits assessment for the city of Baton Rouge, Louisiana, located in the Gulf Coastal region of the United States. The study was designed in collaboration with the U.S. Forest Service to use field data from randomly located plots throughout a community along with local hourly air pollution and meteorological data to quantify urban forest structure, environmental effects, and value to communities. The analysis of trees in Baton Rouge revealed that this area has about 1 036 175 trees with tree canopies that cover 44.6% of the city. The most common tree species are live oak, sweetgum, loblolly pine, pecan-hickory, baldcypress, water oak, crape myrtle, and Southern magnolia. Trees in Baton Rouge currently store about 2 029 342 tons of carbon/yr with an associated estimated value of US$41 million per year. In addition, these trees remove about 48 699 tons of carbon/yr (178 354 tons CO_2/yr) with an associated estimated value of $1.1 million/yr). Baton Rouge's trees are estimated to reduce residential energy costs by $8 million annually and reduce air pollution by 860 tons per year with an associated estimated value of $6.2 million per year.

Wood harvesting rate, haulage methods, and policies in southwest Nigeria: implications for carbon sequestration. Adekunle, V. (*Federal University of Technology, Nigeria; adekunlevaj@rediffmail.com*).

Wood harvesting rate, haulage methods, and policies and their implications for carbon sequestration were examined in a tropical rainforest ecosystem in southwest Nigeria. Data on logging activities and policies for a 3-year period from both the protected and unprotected areas were collected from each state's forestry department. Differences in harvesting rate and in methods of harvesting and removal were found. Policies also differed between states. The total volume of wood removed from the geo-political zone for the 3-year period was 246 784 cubic meters. Log volumes are directly proportional to the amount of carbon that can be sequestered by the forest. The quantity of carbon removed for the period was 2.3 million metric tons (8.4 million metric tons of CO_2). Annual carbon and CO_2 removal was therefore estimated at 760 120.73 and 2.8 million metric tons/yr, respectively. Economically valuable timber species are disappearing from the forest because of incessant and indiscriminate logging, outdated logging and haulage methods, and government policies that favour harvesting over regeneration. The implications of this decline in forest tree species on biological conservation, wood availability, and climate change were discussed. For this forest to continue its environmental role as a carbon sink rather than the present carbon source, conservation measures and better logging policies were recommended.

Estimating harvesting costs and projecting available amounts of logging residues with small-scale forestry in Nasushiobara city, Tochigi prefecture, Japan. Aruga, K. (*Utsunomiya University, Japan; aruga@cc.utsunomiya-u.ac.jp*).

This study estimated supply potentials and costs of small-scale systems operated by a private logging contractor, an individual forest owner, and a forest owners' association using GIS on a regional scale. Total supply potentials of timber and logging residues were estimated as 418 895 m^3 and 254 962 m^3, respectively. Then, economic balances were estimated and available amounts were projected as supply potentials from profitable sub-compartments. Projected available amounts of timber and logging residues were 376 490 m^3 (89.9%) and 203 875 m^3 (80.0%), respectively. Sub-compartments conducted by private logging contractors were almost profitable in the case of selling logging residues at a plant because private contractors' transportation expenses were lower than those of the other systems. On the other hand, there were few profitable sub-compartments conducted by individual forest owners because the number of sub-compartments with extracting distances less than 20 m was small. Logging residue prices of 4 080 yen/m^3 and 6 800 yen/m^3 were examined in addition to a logging residue price of 3 000 yen/m^3. As a result, the number and area of profitable sub-compartments as well as available amounts of logging residues were increased.

Predictive models for estimating the above ground biomass of oil palm plantations using Landsat Thematic Mapper. Asari, N., Suratman, M., Jaafar, J., Md. Khalid, M. (*Universiti Teknologi, Malaysia; nazlinasari@yahoo.com; nazip@salam.uitm.edu.my; jasmee@salam.uitm.edu.my; mazzueen@salam.uitm.edu.my*).

Malaysia is known as the world's top producer of palm oil with a current plantation area around 5.07 million ha. This area has a great potential to provide biomass resources for cellulosic materials for the country. Despite the importance of this resource, a reliable method to assess its availability is lacking. Therefore, the need for a more efficient inventory method is the impetus for research into supplementing ground-based surveys with information from satellite remote sensing. The objectives of this study were to determine the relationships between spectral reflectance recorded by Landsat Thematic Mapper (TM) and oil palm stand variables, and to develop predictive models for estimating the above ground biomass (AGB) of oil palm using TM data. Data sets for the model development were collected from 60 oil palm plantations throughout Selangor, Malaysia. The field stand parameters recorded included stand age, trunk radius, height, DBH, density, crown width, and crown closure. Regression analyses were used to explore relationships between AGB and TM bands and vegetation indices. Relations between TM data and measured oil palm AGB were found to be highly significant ($p<0.00$), with a multiple coefficient of determination (R^2) of 0.52 and standard error of estimates of 1.41 tonnes/ha. The good fit of the biomass model shows the potential of TM data for estimating AGB of oil palm in Malaysia.

Impacts of selective logging on litter input, soil carbon, and nutrient stocks, in the Brazilian Amazon. Bomfim, B., Horwath, W., Silva, L. (*University of California Davis, USA; bdbomfim@ucdavis.ed; wrhorwath@ucdavis.edu; lucascrsilva@gmail.com*), Sérgio Pereira, R., Gatto, A., Emmert, F. (*University of Brasília, Brazil; reginaldosp@unb.br*, *alcidesgatto@unb.br*; *fabianoemmert@yahoo.com.br*).

Litterfall and soil physical and chemical properties were measured in upland (*terra firme*) forest under selective logging. Managed forest tracts (UPAs) were selectively logged in 2003, 2005, 2007, and 2009, establishing a chronosequence to determine logging impacts. Measurements were performed in 15 plots (100 m × 50 m) in 4 UPAs and 1 Protected Area (APA), sampled in Silves, Amazonas, Brazil. In each plot, litterfall was sampled in 0.25-m^2 subplots, soil penetration resistance was determined, and composite soil samples taken (0–10, 10–30, 30–50 cm). Physical and chemical soil properties and litter nutrients (N, P, K, Ca, Mg, S, Al) were determined in the laboratory. Soil properties and calculated litter nutrient inputs were used to compare sites by principal component analyses (PCA). PCA ordinations and cluster analysis showed low dissimilarity between UPAs and APA (<25%), reflecting a limited effect of logging intensity (12.1–19.1 m^3/ha/yr). At the selective logging intensity imposed, the treatments showed minimal effects on ecosystem function. The most affected soil and litter traits were Ca, Mg, and P content and input. High soil organic matter content was found in all UPAs (20.6–64.1 g/kg). These results show resilient carbon and nutrient stocks on managed forest tracts and indicate the sustainability of such selective logging.

Soil impacts and forest operations in the southeastern United States. Carter, E. (*U.S. Forest Service*, *USA; eacarter@fs.fed.us*).

Mechanized forest harvest operations can alter soil physical properties that have the potential to influence subsequent forest productivity and soil sustainability. Soil response to harvest traffic is typically reported as changes in soil volume (compaction) and is of concern to land managers due to its impact on soil structure, soil aeration, soil water availability, nutrient and organic matter status, and erosion potential. Soil compaction status was investigated in several locations within the southeastern United States in the context of soil disturbance types and patterns, machine components, and soil properties. The final compaction status varied in intensity, spatial distribution, and depth of compaction. Final compaction status can be evaluated in the context of maximum compactibility determined via laboratory testing and spatial variability that can be determined with spatial analyses, GPS tracking, or a combination thereof. The movement of soil and water (erosion potential) is a major consequence of harvest activities and was investigated to evaluate site response (soil loss, runoff, nutrient movement) to forest management activities. The effects of machinery on soil resources are expected to intensify as demand for biomass for energy production increases. The impacts that can be expected from forest operations are based on intrinsic soil properties and their response to harvest equipment and systems.

Economic impact analysis of forest road construction using input-output analysis. Chong, S., Lee, H., Jeon, C., Jeon, H., Kim, C. (*Korea Forest Research Institute, Republic of Korea; skchong@korea.kr; hslee77@forest.go.kr; chjeon@forest.go.kr; sun7777@forest.go.kr k561011@forest.go.kr*).

The purpose of the research was to estimate the economic impacts of forest road construction in Korea by using input-output analysis with 2010 inter-industry relation tables (The Bank of Korea, 2011). Inter-industry relation tables were restructured into 29 sections fitting in with the industry of forest road construction. The total length of forest roads in 2012 was about 17 145 km with a density of about 2.69 m/ha. In 2011 total construction of forest roads was about 572 km, at a total cost of 143 552 million Korean won for road construction and management. Hence, the economic impact of forest road construction is as follows: production inducement effects of 2 219 billion won, labor-induced effects of 2 099 people, and value-added inducement effects of 1 704 billion won. Results of the analysis show that the production inducement coefficients and value-added inducement coefficients are somewhat lower than for other industries, but the employment coefficient is somewhat higher than for other industries. In addition, results showed that both influence on other industries and sensitivity to other industries are relatively low.

Identifying priority areas for carbon reservoirs in the Sierra Norte de Puebla, Mexico. Cruz-Huerta, C., González-Guillén, M., Martínez-Trinidad, T., Escalona-Maurice, M. (*Colegio de Postgraduados, Mexico; cruz.carmina@colpos.mx; manuelg@colpos.mx; tomtz@colpos.mx; mescalona@colpos.mx*).

Deforestation and degradation of forest ecosystems modify their structure and function, which may cause a decrease in carbon sequestration and other environmental services. Several population centers in the municipalities of Chignahuapan – Zacatlan, Puebla, in the central region of Mexico, are located on sites with steep slopes and use natural resources intensively. This situation has caused deforestation, damage to other resources, and a decrease in carbon stocks over time. This research used satellite imagery (1986–2010) and GIS techniques to detect land use changes through a probabilistic model. The model, built with biophysical, social, and economic variables, allows the prediction of land use change and deforestation risk from 2010 to 2030. A map of carbon pools was generated using information from forest management programs and GIS. This map together with the deforestation risk map allowed priority areas to be determined for carbon reservoirs. Some management strategies were generated to preserve natural resources and promote payment schemes in the market for carbon services.

Automatic mapping of possible forest operations: a decision support tool for forest planning. Dupire, S., Burger, F. (*National Research Institute of Science and Technology for Environment and Agriculture, France; sylvain.dupire@irstea.fr; frederic.berger@irstea.fr*).

Accessing forest resources in mountainous areas is often difficult and sometimes even impossible. The aim of this work was to develop a numerical tool capable of automatically mapping the areas accessible to different specific harvesting systems. This tool uses different geographic information as inputs, such as digital elevation models, forest road networks, and forest topography. Additional optional geographic information can be provided, such as obstacles for a specific task or information about stand volume. The forest operations considered in this model were harvesting (manual and mechanical) and yarding for three kinds of equipment: skidder, forwarder, and cable crane. For each operation, the model loads the necessary inputs and maps the corresponding accessible area using different scripts coded in the open source Python language. Many outputs are provided for the given operation, allowing the user to geographically evaluate both accessibility and feasibility of forest operations over a large area. This tool provides forest managers useful data for planning forest operations. It enables users to quickly identify the different possible ways for extracting wood from a specific area and can sometimes suggest solutions in the most difficult cases. Inaccessible forests are also mapped, providing information valuable to stakeholders as they decide about the future of such forests.

Optimizing biomass resource allocation for industrial and energy utilization in the light of forest certification. Engler, B. (*University of Freiburg, Germany; benjamin.engler@fobawi.uni-freiburg.de*), Cremer, T. (*Eberswalde University for Sustainable Development, Germany; tobias.cremer@hnee.de*), Brunsmeier, M., Becker, G. (*Albert-Ludwigs-University Freiburg, Germany; martin.brunsmeier@fobawi.uni-freiburg.de; gero.becker@fobawi.uni-freiburg.de*).

Increasing global demand for biomass resources for industrial and energy use is currently leading to high utilization rates of forest biomass. In response to the resulting risk of nutrient loss, forest certification schemes are about to ban harvesting of small-diameter biomass. This step in turn may lead to a shortage of biomass for either industrial or energy use, so knowledge about optimal thinning strategies, in combination with an optimized utilization of the biomass in terms of volumes and economics, is crucial. This study analyzed two different types of thinning operations in 37 forest stands in southern Germany, with a total area of 55.9 ha. Based on real harvested biomass volumes, models were derived to calculate biomass volumes in relation to changing parameters. In particular, the effects of diameter limits on respective volumes of biomass available for industrial and energy utilization could be assessed. Those biomass models were linked with forest harvesting models. Using methods of operations research, an economic valuation of different scenarios of sorting could be derived. Furthermore, effects of forest certification could be assessed in terms of biomass volumes or assortments for different uses, as well as in terms of economic consequences.

Evaluation of environmental impacts of forest harvesting and its effects on sustainability. Freitas, L. (*Federal University of Bahia, Brazil; luiscarlos_ufv@yahoo.com.br*).

Forest harvesting has been shown to have important impacts on sustainability. This research aimed to use the checklist method to evaluate environmental impacts of forest harvesting in eucalypt plantations in southeastern Brazil. The most obvious impacts were described, and mitigating environmental measures were outlined. Impacts from forest harvesting have a strong relation with the physical and biotic environment. Tree removal exposed soil to erosion. To minimize this impact it was suggested that forest waste be preserved on harvesting areas. Impacts of harvesting equipment and vehicles include direct impacts from compaction and indirect ones such as erosion. Defining an optimized layout for traffic was recommended as a mitigating measure for these impacts. Machine traffic during harvesting also damages understory vegetation, which in turn affects animal populations, mainly by reducing habitat. Decreasing the extraction distance through better management of tree falls, proved to be effective in minimizing damage to flora and fauna. In environmental planning of forest harvesting, this checklist can serve as a tool for, helping to identify impacts and recommended mitigation measures, thereby contributing to sustainable, low-impact harvesting.

Evaluation of the drying potential of wood chips inside breathable flexible containers and modeling of changes in moisture content. Fujiwara, M., Iwaoka, M., Matsumoto, T. (*Tokyo University of Agriculture and Technology, Japan; fujiwara@fe.rn.tuat.ac.jp; iwaoka@cc.tuat.ac.jp; tmatsu@cc.tuat.ac.jp*), Inomata, Y. (*Forest Survey, Japan; myumyu_vc3000@yahoo.co.jp*).

The objective of this study was to evaluate the drying potential of wood chips in breathable flexible containers in humid conditions in Japan. Breathable flexible containers were made of 5-mm mesh material. In this study, small, breathable flexible containers were filled with wood chips. During the test, the containers were under indoor conditions, where constant temperature and humidity were maintained using a drying oven. Temperature and humidity inside the containers were measured. Moisture content of the wood chips was also measured periodically. Results showed that the moisture content of the wood chips inside of the containers in an indoor environment decreased continuously during a 2-month period. It could be assumed that the wood chips would be completely dry in the long term. As another result, the drying rate of wood chips inside of the containers depended on the distance from the flexible container's inner surface. Moisture content of wood chips near the surface decreased exponentially with time, and the graph of the change in moisture content of wood chips near the center of flexible container over time was reverse S-shaped. These relationships could be represented by an exponential model and a logistic model, respectively.

Research about raising safety awareness of forestry in Japan. Funasaka, Y., Yamada, Y. (*Nagoya University, Japan funasaka.yukina@f.mbox.nagoya-u.ac.jp; yozo@agr.nagoya-u.ac.jp*).

The Industrial Safety and Health Law established in 1972 concerns safety management for all industries in Japan. This law contributed to the decrease of the incidence and mortality rates of industrial accidents in all industries. Since the recent widespread introduction of high-performance forestry equipment to forestry workplaces, people have been able to work more efficiently and more easily. Despite these changes, forestry has a mortality rate 14 times greater than the average of all industries in Japan. Forestry industrial accidents also occur frequently, because forestry workplaces are still very dangerous. Raising safety awareness of both companies and workers is very important to decrease the incidence and mortality rates of industrial accidents in forestry. Heightened awareness could make forestry workplaces much safer. The purpose of this research was to clarify the current status of and problems with safety awareness, in an attempt to find ways to raise safety awareness. Appropriate educational approaches to greater safety awareness in forestry in Japan are also discussed.

Energy efficiency in intensified production of forest regeneration materials – design of a photovoltaic system for sustainably powering an innovative forestry incubator. Hernandez Velasco, M., Mattsson, A. (*Dalarna University, Sweden; mhv@du.se; amn@du.se*).

Planted forests can help to address problems of global concern, such as climate change, declining biodiversity, and pressure on ecosystems due to high demand for forest products. To be able to profit sustainably from the benefits of planted forests, production rates of forest regeneration materials should be higher than harvesting rates. However, intensive production methods often bring along adverse consequences for the environment. Through the ZEPHYR project, funded by the European Commission under the Seventh Framework Programme, innovative and cost-friendly technologies for pre-cultivation are being developed. They will be integrated into a functional and transportable system for large-scale production of seedlings, with no impact on the environment and without being affected by outdoor conditions. To achieve this, high-efficiency devices with low energy consumption will be used and the incubator will be powered by solar energy. This paper presents the efforts made to reduce the energy loads and optimize the photovoltaic (PV) system. The power system will also be capable of connecting to the electricity grid, using a diesel generator as a back-up, and a battery bank with at least 1 day of autonomy (up to 7 kWh/day) in central European latitudes.

Energy biomass production with downy birch (*Betula pubescens*) on cutaway peatlands. Hytönen, J., Jylhä, P. (*Finnish Forest Research Institute, Finland; jyrki.hytonen@metla.fi; paula.jylha@metla.fi*), Reinikainen, O. (*Vapo Ltd., Finland; olli.reinikainen@vapo.fi*), Ahtikoski, A. (*Finnish Forest Research Institute, Finland; anssi.ahtikoski@metla.fi*).

Forest bioenergy is recovered mainly as a by-product of conventional forestry (e.g., under-sized stems, slash, and stumps). As demand for biofuels increases, production of bioenergy in dedicated plantations is gaining renewed interest. Peat is used as a source of energy in many countries in the Northern Hemisphere. For example, Finland has 60 000 ha in peat harvesting area, and ca. 2 500 ha are removed from peat production each year. Due to the high nitrogen content of the residual peat, these sites show high potential for intensive bioenergy production with woody species. However, deficiencies of phosphorus and potassium can limit biomass production. Wood energy plantations could also act as a carbon sink by absorbing atmospheric CO_2. In the present study, biomass production and its profitability with downy birch (*Betula pubescens*), either by natural regeneration or broadcast sowing, were studied. The study showed that the combination of broadcast sowing and ash fertilization results in thickets with high biomass production. However, rotation length (15–30 years) will be much longer than with willows, for example. Coppice regeneration of natural downy birch stands is a cost-efficient alternative, which results in increased biomass production in the subsequent rotation.

Impact of longer-term storage (3–6 months) on forest chip properties. Jylhä, P. (*Finnish Forest Research Institute, Finland; paula.jylha@metla.fi*).

In 2012, 7.6 million m^3 (15.2 TWh) of forest chips were consumed by Finnish heating and power plants. Most chipping takes place during the winter heating season, when consumption of fuel chips is highest. Currently low machinery utilization in summer results in an increased production cost of forest chips. Costs could potentially be reduced by extending operations beyond the heating season. In addition, ensuring a secure supply of forest chips with reserves produced during the thaw seasons is crucial as the demand for biofuels increases. However, the quality of fuel chips decreases with duration of storage. In summer 2013 a field experiment was established in northern Finland to test the quality of whole-tree Scots pine chips and chips made of delimbed Scots pine or aspen. The impact of longer-term storage on dry matter loss and heating value of the forest chips over a 3- to 6-month period was evaluated. Stockpile temperatures and weather conditions were monitored during the follow-up period.

The storage of Scots pine forest chips – CO_2 fluxes as an indicator of dry matter losses. Jylhä, P., Hytönen, J., Alm, J. (*Finnish Forest Research Institute, Finland; paula.jylha@metla.fi; jyrki.hytonen@metla.fi; jukka.alm@metla.fi*).

Fuel chip quality deteriorates with storage duration. As a consequence, long-term storage is not recommended mainly because of the financial losses associated with a decrease in heating values. The high temperatures recorded in stockpiles indicate increased biological activity, which is manifested as loss of material. Forest chips containing foliage are more susceptible to material losses than forest chips made of stemwood. In the present study, a method based on measuring CO_2 fluxes to quantify dry matter losses and CO_2 emissions was tested in northern Finland. The forest chips tested were made of small-diameter Scots pine, either delimbed or undelimbed. A portable infrared gas analyzer was used to measure weekly CO_2 fluxes from several locations within the stockpiles during the storage period of 3–6 months. Carbon losses were derived from a model that included temperature as its driving variable, and the results were compared with the dry matter losses in pieces of cellulose placed systematically in the chip piles. If there is a strong correlation between CO_2 fluxes and material losses, this method would be a novel way to assess the carbon balance of forest chip production systems, as well as the dry-matter losses within the storage period.

Areas of forest required to maintain sustainable, local wood supplies in Pacific Northwest, USA, communities. Keefe, R., Brooks, R., Smith, A. (*University of Idaho, USA; robk@uidaho.edu; rbrooks@uidaho.edu; asmith@uidaho.edu*).

An analysis was conducted to determine how much forested area is required to provide baseline minimum sustainable timber yields to communities of different sizes in a range of northwest U.S. forest types, in order to establish benchmarks for sustainability. The Forest Vegetation Simulator was used to project current Forest Inventory and Analysis (FIA) plot data forward for 60 years under common silvicultural systems in each forest type. The timberland area requirements for individuals and communities of different sizes to supply their own wood locally were established and summarized spatially. Advancing local wood use is an important opportunity to promote forestry among a general public that values local products. Opportunities for communities to procure local wood from private, state, and federal forestlands for sustainable timber production are discussed.

Effects of elemental composition in wood and different tree compartments on the quality of chips for fuel. La Porta, N., Cerasino, L. (*Edmund Mach Foundation, Italy; nicola.laporta@fmach.it*; *leonardo.cerasino@fmach.it*).

Biomass combustion produces such pollutants as particulate matter, NO_x, and ozone, which severely affect air quality. In this context, the elemental characterization of wood and the element allocation among tree components can provide important information about the quality of the derived wood fuels and give insight into the choice of the most appropriate combustion technique and the right wood fuel for a given combustion technique. Moreover, knowledge of the different concentrations of elements in the different plant tissues can lead to the identification of the best harvesting strategy aimed at producing wood fuel with the lowest possible environmental impact. This work focused on the allocation in three tree compartments (foliage, branches, and stem) of five important macroelements (K, Mg, Ca, N, and P) in Norway spruce (*Picea abies*), and pointed out the possible effects of different harvesting strategies and tree age on the quality of the wood fuels. Results showed that the stem-only harvesting system is preferable to whole-tree harvesting in terms of mineral content loss. Results also showed that it is preferable to avoid biomass from young trees because of the poorer fuel quality of the wood chips.

Mapping of forest disturbance in northeast China using time-series remote sensing data. Li, S., Liu, Q., Li, Z., Chen, E. (*Chinese Academy of Forestry*, *China; lism@caf.ac.cn; liuqw@ifrit.ac.cn; lizy@caf.ac.cn; chenerx@caf.ac.cn*).

Forest disturbance caused by natural or anthropogenic factors is one of the important drivers of change in the structure and function of forest ecosystems and forest carbon dynamics. The high temporal and spatial variability of forest disturbance events

and of forest biomass loss is a major source of uncertainty in understanding the global carbon cycle. Changes in land surface reflectance and temperature can be attributed to changes in the biophysical characteristics of terrestrial surfaces and can indicate pre-disturbance and post-disturbance conditions. This study uses a forest disturbance index model and object-based image analysis to detect forest disturbance areas in northeast China and to map disturbance severity in a given year by combining time series MODIS vegetation index data and land surface temperature data. The model will then be validated with ground observation data or high spatial resolution remote sensing data.

Technical and technological evaluation of forest areas for machine timber harvesting on the basis of the Cone Index (CI) in European forestry. Lubera, A. (*State Forests, Poland; adamlubera@wp.pl*), Sowa, J. (*University of Agriculture in Cracow, Poland; rlsowa@cyf-kr.edu.pl*).

The previous decade could be called a "decade of multi-operational machines." In that period, the number of harvesters and forwarders used in European forestry increased considerably. Depending on the country, the shortwood volume intended for harvesting is estimated at 20–80% of the total timber harvest in a given year. Given these estimates, it is necessary to determine the types of forest habitats in which the use of multi-operational machinery will bring an economically acceptable return of these machines in the forest environment. One of the most important effects of machine harvesting on the forest environment is the impact on soil. To evaluate the technical and technological impacts of mechanized harvesting on forests, the present study uses the Cone Index (CI) values obtained during field measurements using the 06.15.SA penetrometer (manufactured by Eijkelkamp Agrisearch Equipment, the Netherlands). Research was located in typical European lowland pine forest habitats. The results were related to U.S. standards (American Society of Agricultural Engineers (ASAE) S313, ASAE EP542) concerning forest soil types for the use of multi-operational machines in timber harvesting. The method and characteristics obtained will allow the technical and technological evaluation of forest areas through forestry activity.

Analysis of traffic performance in forest roads using computational methods. Machado, C. (*Federal University of Viçosa, Brazil; machado@ufv.br*), Oliveira, R. (*Federal University of Piauí, Brazil; robinho@terra.com.br*).

Forest roads are the main way of connecting forests and companies. Therefore, there is a need for defining not only the required maintenance activities, but also the exact time for such intervention. Starting from this premise, this paper presents the results of an assessment of two methods of classifying the quality of unpaved roads. The objective was to determine which one better reflects actual conditions and thus can serve as the basis for a management system for unpaved roads. Main defects in forest roads were measured following the unsurfaced road condition index (URCI) method. Data collected formed a database for testing the efficiency of using artificial neural networks (ANN) in the management of forest roads with the goal of minimizing costs and traffic stoppage. It was concluded that the performance of ANN was superior to that of the URCI method.

Durability of chemically stabilized soils for forest road applications. Machado, C., Portugal, C. (*Federal University of Viçosa, Brazil; machado@ufv.br; carlamacport@terra.com.br*), Portugal, R. (*Oregon State University, USA; rsallesp@terra.com.br*).

The durability properties of mixtures of two soils for forest road applications were investigated using laboratory wetting and drying durability tests. Soil mixtures were as follows: soil stabilized with industrial waste grits; soil improved using lime or cement; and soil stabilized with grits and improved using lime or cement. Grits content was 24% in relation to soil dry mass. Lime and cement contents were 10% and 20%, respectively, in relation to grits dry mass. Specimens were compacted at the standard and modified Proctor effort, and mixture specimens were cured for 7 days in a climate-controlled room. The testing program data showed that the soil-lime, soil-cement, soil-grits-lime, and soil-grits-cement mixtures endured all cycles in the durability test. Mixtures of soil 1 and lime compacted at the modified Proctor effort presented the best mechanical response in the durability tests, showing losses of approximately 7%. For soil 2, the best result was for the soil-grits-cement mixture compacted at the modified Proctor effort, showing losses of approximately 9%. To meet durability standards, the soil-grits mixtures showed potential for road engineering applications only in association with lime or cement.

Evaluation of the wood hauling logistic performance in farm forest areas using Petri net. Machado, R., Machado, C., Gomes, M. (*Federal University of Viçosa, Brazil; raianemachado@ufv.br; machado@ufv.br*; *mgommez@terra.com.br*), Portugal, C. (*Oregon State University, USA; carlamacport@hotmail.com*), Portugal, R. (*Oregon State University, USA; rsallesp@terra.com.br*).

The present work uses a model of logistic performance to evaluate production chains centered on the operational cycle time elements of wood transport. A cellulose-producing company in the state of Minas Gerais, Brazil, was used as a case study. The model of chain logistics of wood transport used the Temporal Petri Net for working with two times that correspond to a sensitization period. Their properties are as follows: simulation, dynamic; determinist; continuous; and temporal in the transitions. Scenarios, with the same variations in the two wood-producing regionals were created, to evaluate the operational and economic performance. Rio Doce and Cocais das Estrelas The variations applied to the scenarios were: improvement of the forest roads; increased number of loaders, and improvement of garage efficiency. For both regionals, the scenario with the three variations presented the largest reduction in cycle times of wood transport in relation to the current situation, being 19.24% and 21.48%, respectively, for Rio Doce and Cocais das Estrelas. The analyzed operational cost is the value paid for the freight, not including the investment costs. Both regionals, Rio Doce and Cocais das Estrelas, presented a larger reduction in the Scenario 7, of 20.09% and 21.22%, respectively.

Ergonomic evaluation of skyline models used in forest extraction. Machado, R., Machado, C. (*Federal University of Viçosa, Brazil; raianemachado@ufv.br; machado@ufv.br*), Penna, E. (*Federal University of Mato Grosso, Brazil; penna@yahoo.com.br*), Portugal, C. (*Oregon State University, USA; carlamacport@hotmail.com*).

This study was conducted at a forest company, located in the municipality of Cerro Azul, Paraná, Brazil. The objective of this study was an ergonomic evaluation of three skyline models, K301, K501, and K601 used in the extraction of whole *Pinus* spp.

trees in mountainous regions. The study was based on a questionnaire completed by the operators of three existing towers. Respondents were asked to evaluate the following variables: access to cabinet work, working position of the operator, operator seat, controls and instrumentation, climate in the cabin, cockpit visibility of the field, exhaust fumes and dust, and vibration. The K301 and K501 models do not meet ergonomic standards; therefore, their operators are susceptible to work-related risks. The K601 model has satisfactory ergonomic conditions.

Thinning of Norway spruce stands under changing climate. Mäkinen, H. (*Finnish Forest Research Institute, Finland; harri.makinen@metla.fi*), Sirén, M., Ala-Ilomäki, J., Lamminen, S. (*Finnish Forest Research Institute, Finland; matti.siren@metla.fi, jari.ala-ilomaki@metla.fisami.lamminen@metla.fi*), Mikkola, T. (*University of Helsinki, Finland; tuomas.mikkola@helsinki.fi*).

In Finland, 60% of logging is carried out while the soil is frozen, because Norway spruce stands are susceptible to logging damage and soil compaction. The anticipated climate change has raised the question of whether a dry autumn would be a better season for thinning than a mild winter with little snow but high soil moisture. Two harvester working methods were compared in the thinning of Norway spruce stands. In the normal harvester working method, trees removed farther away from the strip roads were processed outside the strip roads. In the protective method, the harvester processed as many trees as possible on the strip road. The protective harvester working method increased the harvester time consumption by 5%, but a higher proportion (86–92%) of the total logging residue potential was brought to the strip roads. The proportion of damaged trees exceeded 4%, the limit recommended for forestry operations. After two to four forwarder passes, the proportion of deep ruts remained low. It was concluded that the prerequisites for a successful thinning on unfrozen soil are favourable weather, soil, and stand conditions. On dry soils with high bearing capacity, ruts remain shallow. Furthermore, a high amount of logging residue decreases rut formation.

Opportunities and challenges in evaluating medium-term climatic impacts: the U.S. Northern Forest Futures Project. Moser, W.K., Shifley, S. (*U.S. Forest Service, USA; wkmoser@fs.fed.us; sshifley@fs.fed.us*).

As discussions of hypothesized climate change move from the theoretical to the applied, questions arise as to how the forested landscape might be changed. Challenges stem from separating demographic, economic, and normal ecological succession effects from the effect of medium- and long-term changes in regional and local temperature and precipitation regimes. The Northern Forest Futures Project (NFFP) seeks to accomplish this very task for the medium term (2010–2060) for the north-central and northeastern United States. With 69 million ha of forestland and 124 million people, this region is the most densely forested and most densely populated quadrant of the United States. The NFFP looked at ecological, climatological, demographic, and economic factors that the U.S. Forest Service predicts will be extraordinarily influential in large-scale northern forest management needs over the next 50 years. This presentation highlights several of those factors, including: (1) decreasing age class diversity, (2) decreasing forest land area, and (3) the likelihood that management intensity for timber will not change and thus is unlikely to materially influence the first two factors. The advantages and limitations of these types of studies are discussed, and what can be predicted and what cannot are pointed out. In the next several decades, climate change appears to complicate current ecological and demographic trends, rather than radically redirecting them.

Critical factors in damage to the environment from the production chain of charcoal in Brazil. Mota, F., Castro, A., (*University of Brasília, Brazil; fabriciacmm@yahoo.com.br; antonio.gomesdecastro@gmail.com)*, Pereira, R. (*University of Brasília, Brazil; reginaldosergiopereira@gmail.com*), Braga, C. (*National Confederation of Agriculture, Brazil; camila.braga@cna.org.br*), Almeida, G. (*University of Brasília, Brazil; gloriaalmeidaflorestal@hotmail.com*), Mota, D. (*Federal University of Lavras, Brazil; diegomenezmota@gmail.com*).

Research in the production chain of charcoal is needed to detect bottlenecks and suggest initiatives aimed at increasing sustainability. The aim of this study was to identify the critical factors, both technological and non-technological, leading to environmental damage from the production chain of charcoal in Brazil derived from planted forests. The methodology consisted of diagnostic analysis of the charcoal production chain, through the analysis of secondary data and interviews with experts and the panel-of-judges method to identify the critical factors. The critical technology-related factors of environmental damage were the (1) lack of production of ovens for recycling gas and (2) lack of development and incorporation of new technologies. New technologies are expensive to develop and adopt, making innovation impractical both for larger firms and for smaller independent producers of charcoal. Low production of charcoal from planted forests was considered a critical non-technological factor.

Forest woody biomass collection through a bundling process in a mountainous area. Nitami, T. (*University of Tokyo, Japan; nitami@fr.a.u-tokyo.ac.jp*), Kondo, R. (*Dream Works, Co. Ltd., Japan; kondo@dw-net.co.jp*), Suzuki, K. (*Amerika-ya Co. Ltd., Japan; amerikaya@able.ocn.ne.jp*).

This work considered operations for the collection of woody residue for energy use after logging in a mountainous area of Japan. Residue was bundled by a truck-mounted bundler. Scheduling the machine was easy and efficient because of its mobility. The use of GIS in making a feasible operation schedule is discussed. Each bundle of woody residue contained about 500 kg of biomass in a thick log shape that was compressed into one-third of the original volume of slash. Bundles were kept at the side of the forest roads. Storing them in the forest avoided the need for additional storage space at the site of the energy plants, which are typically located in an urban area. Collection of this woody biomass for energy must be balanced with local people's needs, such as fuel for home heating. Collection operations on a business scale are discussed. Timber harvesting operations in the region are also discussed, with attention to forest road networks in this mountainous area.

Log distribution planning for efficient wood supply chains. Opferkuch, M., Smaltschinski, T. (*University of Freiburg, Germany; martin.opferkuch@fobawi.uni-freiburg.de; thsm@gmx.de*), Müller, M. (Bavaria State Forest Enterprise*, Germany; martin.mueller@baysf.de*), Jaeger, D. (*Albert-Ludwigs-University, Germany; dirk.jaeger@fobawi.uni-freiburg.de*).

Supply chain performance is increasingly evaluated by energy efficiency and environmental aspects in addition to economics. Transport plays a key role in all forest biomass supply chains as a major cost factor, energy user, and origin of emissions. Three-fourths of the Bavaria State Forest Enterprise (BaySF) annual cut volume of 5 million.m³ of timber is processed at a single

mill. Traditional planning shows little flexibility in the face of major market changes, such as after calamitous events. The total transport distance of 19 million km for 3 million m³ of softwood assortments is associated with enormous costs, energy consumption, and emissions. Optimal distribution planning requires solving the transportation problem so that demand for forest biomass is met and the raw materials are distributed to customers' sites at minimal transport distance. Optimal distribution planning has been realized with operations research methods such as linear programming and combinatorics. Including back freight optimization the average transport distance for cargo and empty runs was reduced from 175 km to 139 km with savings in costs, energy, and emissions of up to 24%. This method has been successfully applied at BaySF since 2013 for annual log distribution planning and weekly dispatching. The proposed transport optimization increases supply chain performance and helps the forest products industry maintain its good ecological reputation.

Use of LiDAR technology to create a management plan for an urban park in Belo Horizonte, Minas Gerais, Brazil. Petean, F.C.S., Silva Filho, D.F., Polizel, J.L., Görgens, E., Zanlorenzi, H.C.P. (*University of São Paulo, Brazil; coelho.petean@gmail.com*), *dfilho@usp.br; jlpolize@usp.br, gorgens@usp.br, helenapz@usp.br*).

Treefall from wind is one of the main problems identified by managers of urban forests and parks, who are increasingly using remote sensing tools to assist in the management of these areas. The present study aimed to create a management map of an urban park in the city of Belo Horizonte, Minas Gerais, Brazil, which highlights areas that represent greater risk to visitors from falling trees and branches due to wind action. After the LiDAR data were converted, normalized, and filtered, a digital canopy model (DCM) was extracted from the point cloud, transformed into an image file, and then classified according to tree height. The wind circulation pattern of the site was calculated using the DCM height information. The areas more susceptible to falling trees and branches were identified through analysis of the layout of the park (e.g., paths, common areas, and recreational areas), the image classified by tree height, and the wind circulation pattern image. Finally all the data were put together to complete the park's management map as a tool for facilitating the decision-making process.

Slope restrictions on land-use practices: consequences for Borneo of different definitions and limits. Putz, F. (*University of Florida, USA; fep@ufl.edu*), Griscom, B., Ellis, P. (*The Nature Conservancy, USA; bgriscom@tnc.org; pellis@tnc.org*).

Tropical silviculture is being driven into the hills by increases in both global populations and per capita consumption of food, fuel, and fiber. With increased slope angles and lengths, the likelihood of erosion and mast-wasting events increase, logging costs escalate, and problems with logging damage are exacerbated. Unfortunately, most slope-related environmental guidelines promulgated by governmental and non-governmental bodies are unclear. Rather than prohibiting specific activities on slopes above a specified grade, most guidelines recommend adoption of appropriate timber yarding (e.g., switching to aerial systems). Another common deficiency is that slope lengths (or the areas over which slopes are averaged) are not specified. In Indonesian Borneo we used aerial LiDAR to construct digital elevation models (DEMs) with different pixel sizes for five timber concessions. The proportion of those concessions with slopes >40% (the legal limit on ground-based harvesting) ranged from 35 to 85% for 1 m pixels and 12 to 60% for 30 m pixels. The pixel size effect decreased with topographic rugosity. A DEM constructed for the same areas with Aster data (30 m pixels) underestimated slopes measured on the ground and with LiDAR by 10–50%. If the DEM is applied to all production forests in Kalimantan, however, about 20% of their area is on slopes >40%.

Impacts of forest resource competition on future bioenergy production in Austria – answers from a system dynamics model. Rauch, P. (*University of Natural Resources and Life Sciences, Austria; peter.rauch@boku.ac.at*).

Uncertainty will increasingly affect outcomes of forest management decisions. Research on methods that incorporate uncertainty into forest planning models is of increasing relevance. Storms and bark beetle infestations are the most significant causes of forest damage in Central Europe, and have a massive impact on the security of the wood supply. Recent trends such as restrictions on imports, new competitors (e.g., wood plastic composites and biomass to liquid) for raw material, and rising demand for wood for bioenergy production further threaten the security of the wood supply. In order to assess risks and their mid- and long-term impacts on wood supply a system dynamics model of the Austrian wood supply was developed that includes a stochastic simulation of the main risk agents. The model examines the future annual harvests of Austrian forests and evaluates wood supply security under different scenario assumptions. Simulation results provide insights on projected future wood supply security for saw logs and pulpwood used for energy and reveal counterintuitive effects under the climate change scenario. Even though salvaged wood volumes were clearly increasing, the supply of all roundwood assortments declined and supply security decreased because of a marked reduction in wood removals after damaged forest sites had been harvested.

Amount and quality of residue biomass generated in forest harvesting systems for pine and eucalypt plantations in southern Brazil. Sanquetta, C., Sanquetta, M., Dalla Corte, A., Lourenço Rodrigues, A. (*Federal University of Paraná, Brazil; carlos_sanquetta@hotmail.com; mateus.sanquetta@hotmail.com; alourencorodrigues@gmail.com*; *anapaulacorte@gmail.com*), de Miranda, D. (*Federal University of Mato Grosso, Brazil; mirandaufmt@hotmail.com*).

Tactical harvesting planning helps forest companies to improve their performance, reducing harvesting costs and environmental impacts by the rational use of wood residues. Pine and eucalypt are the most important sources of industrial timber in Brazil, producing ca. 270 million m^3 of roundwood a year. This study aimed to inventory wood residues generated by pine and eucalypt harvesting systems in a large-scale forest enterprise. The system for pine was composed of harvester-skidder-slasher and for eucalypt of harvester-forwarder. The study site was the north region of Santa Catarina, southern Brazil. A tactical systematic sampling was applied to sample wood debris in four 17-year-old stands just after harvesting. Log length, diameter, quality (e.g., chipped, broken, rotten, forked) at the stand border and inside it were measured. The pine residue (151.86 and 67.57 m^3/ha, for border and inside, respectively) was much higher than that of eucalypt (22.61 and 23.71 m^3/ha). There was a concentration of debris of pine along the stand border, but it was not noticed for eucalypt. For both genera the wood debris is useable mainly for bioenergy due to low quality and limited size. The main cause of pine residue generation is the slasher, which works close to the stand border.

Assessment of workers' physical workload in semi-mechanized silviculture operations in mountainous regions in Brazil. Schettino, S., Minette, L., Souza, A., Marzano, F., de Moraes, A. (*Federal University of Viçosa, Brazil; stanley.schettino@oi.com.br; minette@ufv.br; amaury@ufv.br; felipe.marzano@ufv.br*, *angelo.moraes@ufv.br*).

In mountainous regions, forest operations can be performed only by manual or semi-mechanized methods, which present a number of ergonomic problems. A high physical workload, high noise and vibration levels, high forces exerted, awkward postures, and repetitive movements may cause damage to the health and welfare of workers. The objective of the study was to evaluate the operators' physical workload. Operations analyzed were semi-mechanized hole digging and semi-mechanized weed cutting, in eucalyptus plantations. The workers' heart rate was measured during the work day in the mountainous terrain of a pulp production company in Brazil. These data were used to calculate the cardiovascular workload (CVW) following an appropriate methodology. According to this methodology, the CVW limit is 40%, which represents the heart rate during labor as a percentage of the maximum usable heart rate. The CVW for the hole-digging operation activity was calculated as 50%, exceeding, the limit. This value corresponded to a heavy physical workload, requiring reorganization of the work by introducing breaks for resting. The weed-cutting operation had a lower CVW and did not require work reorganization.

A transferable framework to interpret quality results of large data sets. Smith, D., Metzger, S., Taylor, J. (*National Ecological Observatory Network, USA; dsmith@neoninc.org; smetzger@neoninc.org; jtaylor@neoninc.org*).

The ability to assess data validity is essential to any investigation. Manual "eyes on" assessments of data quality have been dominant in the past. Yet, as data set sizes continue to increase, so does the time required to assess their quality. This has resulted in the automation of many quality assurance and quality control (QA/QC) analysis frameworks to assess data quality. Unfortunately, the interpretation of quality results from QA/QC analyses can become quite challenging with large data sets. Therefore, the authors have developed an automated framework to summarize data quality information and facilitate user interpretation. Briefly, the framework consists of first compiling data quality information and then presenting it through two separate schemes: a quality report and a quality summary. The quality report presents the results of specific quality analyses as they relate to individual observations. The quality summary takes a spatial or temporal aggregation of each quality analysis and provides a summary of the results. Included in the quality summary is a final quality flag, which uses a predetermined threshold to assesses whether the observations used to create a data product are valid. Furthermore, this framework can aid in problem tracking and resolution, should sensor or system malfunctions arise.

Production target for workers using hole-digging machines to plant eucalyptus seedlings, as a function of ergonomic factors. Souza, A., Marzano, F., Minette, L., de Moraes, A., Schettino, S. (*Federal University of Viçosa, Brazil; amaury@ufv.br felipe.marzano@ufv.br; minette@ufv.br; angelo.moraes@ufv.br; stanley.schettino@oi.com.br*).

The objective of this study was to determine the production target for workers operating hole-digging machines for planting eucalyptus seedlings in Brazil, as a function of ergonomic factors. The methodologies for motion and time study and ergonomic work analysis were used to quantify and qualify the effect of each of six ergonomic factors on operators' capabilities during an 8-hr work shift. The factors analyzed were vibration, noise, physical work load, heat, repeatability, and forces and postures. Results indicated that the values obtained during the work day for all factors except repeatability for the established production target of 800 holes, exceeded the workers' physical capabilities. The critical factor was vibration, which caused 60% of the rest breaks per shift. These rest breaks may include performing lower level workload activities, except those related to the critical factor. The production target was adjusted to the new work system. Thus, the effective work turn time should not exceed 40%. In this case the production target should decrease from 800 holes to 667 per turn to avoid health problems due to excessive vibration.

A case study of wood fuel utilization by community forestry for sustainable, cost-effective management of a local forest in Japan. Takamura, K., Mori, D. (*Kochi University, Japan; b13m6f29@s.kochi-u.ac.jp, b104m153@s.kochi-u.ac.jp*), Gotou, J. (*Kochi University, Japan; ryosuke@kochi-u.ac.jp*), Suzuki, Y.K. (*Kochi University, Japan; ysuzuki@kochi-u.ac.jp*).

High-performance mechanized operations are generally considered necessary both for reducing costs and for increasing profits in forest operations. However, especially for community forestry, it can be effective to use operation methods that do not have high efficiency but that require only low investment. Self-hired labor can reduce costs; in contrast, if one hires employees and uses corporate-style management, higher profits would be required to pay for labor and management. A case presented in this paper is a woody biomass utilization system in a local community in Kochi, Japan. In this system low-quality residue logs are recovered and processed for fuel by community members, and then burned with high-efficiency wood fuel boilers operated in a local community center. The large amount of money formerly used to pay for imported fossil fuel, now goes instead for wood fuel produced in the area. Utilization of low-quality logs gives community members an incentive to manage local forests, for example, by commercial thinning and small-scale final cutting. In this case management of community forests by local people leads to sustainable management of the forests.

Analyzing the potential and use of forest waste biomass in the production of clean energy in Nepal. Uprety, D. (*Multi Stakeholder Forestry Programme, Nepal; dharam.uprety@gmail.com*).

Forest management operations and clearing of invasive shrub species by forest users are the sources of forest waste biomass, used as raw materials in bioenergy production in Nepal. Nepal imports 420 000 metric tons of coal annually, and brick-making operations are the largest consumers. Forest waste biomass can be an alternative source of energy. The total biomass of stems, branches, and leaves is an estimated 429 million metric tons (air dry) in Nepal and hence several private enterprises have initiated production of bio-coal in different forms. A study carried out in early 2013 in seven districts of Nepal in order to know the potential of forest waste biomass found that 76% of community forests in Nawalparasi, 49% in Rupandehi, 22% in Kapilvastu, 34% in Parbat, 60% in Baglung, 88% in Myagdi, and 25% in Dang have potential for the production of bio-coal. This paper gives an overview of how local communities and the private sector have developed ways of producing bioenergy, and provides insight into how such initiatives contribute to meet energy demands in Nepal.

Establishment of logistics for an economical bioenergy supply chain in Japan. Yoshida, M. (*University of Tokyo, Japan; yoshida@fr.a.u-tokyo.ac.jp*).

Logistics is an important issue for the economic success of the bioenergy business. The increasing demand for forest biomass for energy use is expected to intensify forest management. Forestry companies and the Japanese government have promoted mechanization of forestry and introduced forestry equipment from abroad in order to achieve high productivity. However, the density of forest roads across Japan remains low, and road width is often inadequate because of difficult, steep terrain. Therefore, full use of forestry machinery and vehicles has not been reached in Japan. It is also important when establishing efficient bioenergy logistics to understand the differences between transportation methods available for forest roads versus public roads, and differences in the distribution of biomass among logging systems. This study investigated available biomass production and transportation methods including the newest equipment, and calculated production and transportation costs of different systems based on the condition of the forest road network and terminal landing. Then, the appropriate logistics for the bioenergy supply chain was discussed for the first stage of bioenergy utilization in Japan.

GENERAL POSTER SESSIONS

IUFRO Division 4: Forest Assessment, Modeling and Management

Potential of canopy stratification in modeling planted forests in a changing world: application to pine plantations in Nigeria. Adesoye, P. (*University of Ibadan, Nigeria; adesoyepet@yahoo.com*).

Canopy stratification is an important concept in tropical forest ecology. Views differ considerably on the existence and identification of canopy strata. Canopy stratification studies have focused on mixed forests. Little has been done to investigate canopy stratification in pure plantations. This paper investigates the existence and potentials of canopy stratification for improving yield models under pure plantations. Pine plantations in Oluwa Forest Reserve, Ondo State, Nigeria were investigated. Individual tree growth variables, including diameters, heights, crown measurements, and inter-tree competition measures were obtained in 2010 on twenty-five 0.04-ha plots representing five different stands planted between 1979 and 1991. Visual assessments of the trees within each plot were also done to classify them into four strata (i.e., dominant, co-dominant, intermediate, and suppressed). Tree variables under the canopy strata were analyzed using ANOVA, while yield models with and without canopy stratification were tested using regression analysis. Significant differences were observed among the canopy strata in terms of mean DBH, basal area, stem volume, and competition index. The yield models for the different canopy strata had the least prediction error sum of squares compared to the model for the pooled trees. It was found that canopy stratification improved model accuracy.

A simplified method for assessing forest health changes during 7 years using *Triplochiton scleroxylon* stands in southwest Nigeria. Adesoye, P. (*University of Ibadan, Nigeria; adesoyepet@yahoo.com*).

Forest health assessment is one of the major steps in ensuring sustainable management of forests. However, there are many divergent perspectives on the choice of forest health indicators. This paper presents a simplified approach to forest health assessment. The stands investigated were located in the experimental station of the Forest Research Institute of Nigeria, Onigambari, Oyo State. Some forest health indicators were formulated and assessed in 2006 and 2012 on fourteen 0.04-ha plots in four different stand ages planted between 1973 and 1976. The measured indicators included tree stability, stem vigour, incidence of crown injury, tree density, and incidence of leaf or stem damage from disease or harmful insects. Climatic data between 2005 and 2011 were also obtained for the station. The results indicate an increase in the number of trees/ha susceptible to wind throw between 2006 (27 trees) and 2012 (38 trees). Number of trees/ha in the high vigour class dropped from 18 in 2006 to 13 in 2012. Incidence of crown injury/ha decreased from 96 cases in 2006 to 54 in 2012. An increasing trend was observed in annual precipitation. Health implications and strategies for management are discussed in the paper.

Evaluation of carbon content in forests of northeastern Mexico. Aguirre Calderón, O., Jiménez Pérez, J., Treviño Garza, E., Alanis, E (*Universidad Autónoma de Nuevo León, Mexico; oscar.aguirrecl@uanl.edu.mx; javier.jimenezp@uanl.mx; eduardo.trevinogr@uanl.edu.mx;. alanis_eduardo@yahoo.com.mx*).

The objective of this study was to communicate some initial lessons about the practical challenges of designing and conducting measurements of carbon pools in Mexico. Equations of biomass as a function of the typical diameter for *Pinus pseudostrobus*, *P. teocote*, and *Quercus* spp. were developed for temperate forests of northeastern Mexico. Carbon content of the species was determined with an organic carbon analyzer. The results allowed the construction of biomass and carbon content tarif tables and charts, through which carbon contained in tree species of pine-oak mixed forests, oak-pine mixed forests, and pure pine stands was evaluated. The carbon percentage in *P. pseudostrobus* was 50.35, in *P. teocote* 47.78, and in *Quercus* spp. 48.43. Carbon content tables for pure stands of the two pine species were built for different site indices. The results of the carbon content evaluation in different types of forest were: pine-oak forests 45.24 Mg/ha, oak-pine forests 64.20 Mg/ha, pure forests of *P. pseudostrobus* 73.18 Mg/ha, and *P. teocote* forests 47.01 Mg/ha. Two inventory techniques for the estimation of forest carbon in different forest structures are discussed, and field measurement guidelines for mixed and pure stands are presented.

Systematic review of impacts of the white spruce tree improvement program in the boreal forest of Canada: A meta-analytical approach. Ahmed, S., LeMay, V., Bull, G. (*University of British Columbia, Canada; suborna@alumni.ubc.ca; Valerie.LeMay@ubc.ca; gary.bull@ubc.ca*).

Tree improvement programs in Canada started in the early 20th century, but the specific starting dates, species, and processes differ among provinces. As a result, there is not yet a common framework for measuring gains from tree improvement programs. Further, data for all trials in all provinces have not been amalgamated or summarized across trials. In this study, data from white spruce (*Picea glauca* (Moench) Voss) tree improvement programs across the boreal forest of Canada were combined and analysed using a meta-analytic approach. The combined database includes meta-data extracted from publications for >60 sites and 400 white spruce and white spruce hybrid provenances from six provinces of Canada with active white spruce tree improvement programs. These meta-data were used to quantify any gains achieved from selection, specifically, the expected yield improvements through first-generation genomic selection, using a hierarchical mixed-effects model. A major challenge in estimating the selection gain is that most trials are still very young relative to rotation ages currently used for white spruce in Canada. Therefore, this work also examined the use of age-to-age correlations using an error correlation structure for varying measurement intervals to improve models.

Effect of pistachio canopy on the spatial distribution of soil chemical characteristics in the Zagros forests of Iran. Akhavan, R. (*Research Institute of Forests and Rangelands, Iran; akhavan@rifr-ac.ir*), Tahmasebi, M., Hosseini, V. (*University of Kurdistan, Iran; tmaryam56@yahoo.com; vahidit@yahoo.com*).

In arid and semi-arid ecosystems, isolated trees have an important effect on soil properties and can determine the structure of the soil fauna and herbaceous communities under the tree. The aim of this study was to understand the effect of pistachio canopy on

the spatial distribution of soil nutrients (organic carbon, N, P, K), as well as Na and Li. Soil samples were taken under and around a pistachio (*Pistacia atlantica* Desf.var.*Kurdica*) tree in the Zagros region of western Iran. The samples were taken every 2 m and then at 50-cm intervals in a regular grid of 20 m × 20 m around the tree, in order to analyze the spatial properties using geostatistics. Total N content and soil organic carbon were higher under the tree canopy. Phosphorus content also was higher under the tree. Potassium decreased with distance from the tree base. Sodium had a medium spatial distribution related to tree canopy; Li showed a sparse spatial pattern and its distribution seems to be independent of the tree position. These results support the hypothesis that the presence of a tree differentially affects the spatial distribution of the various nutrients depending on their chemical characteristics.

Three experiences with geostatistics application for estimation and mapping of forest stock in the Caspian region of northern Iran. Akhavan, R. (*Research Institute of Forests and Rangelands, Iran; akhavan@rifr-ac.ir*).

The purpose of this paper was to compare the application of geostatistics for estimation and mapping of forest stock attributes among a natural hardwood unmanaged forest (intact without any intervention), a natural hardwood managed forest (harvested two times), and a plantation forest (18-year-old pure maple) in the Caspian region of northern Iran. Different systematic grids with proportional plot sizes were set up for sampling. Experimental variograms were calculated and plotted for basal area (BA) and stem density in these forests based on the inventoried georeferenced plots fitted by appropriate models. Estimation and mapping were made by ordinary block kriging and evaluated by cross-validation. Results showed that there is no spatial structure for BA and stem density in the natural managed forest. In the natural unmanaged forest spatial structure was found only for stem density, and in the plantation forest spatial structure was found only for BA. Therefore, it was concluded that geostatistics is able to capture and accurately describe the spatial variability as well as estimates and maps for some tree attributes in unmanaged and plantation forests; however, due to high spatial variability, it has no application in managed forests.

Ecological adaptation of the shea butter tree (*Vitellaria paradoxa* C.F. Gaertn.) along a climatic gradient in Benin, West Africa. Akpona, T. (*University of Abomey-Calavi, Benin; ajeandidier@gmail.com*).

This study assessed the ecological adaptation of shea butter trees based on their dendrometric and production traits in four shea parks established in different climatic zones of Benin. A total of 99 rectangular plots of 50 m × 30 m were established within the four parks using a random sampling scheme. In each plot, all trees with DBH 10 cm were inventoried and measured for stem and crown diameters, and total height. Production of 120 productive shea trees was quantified in the four parks. Data collected were used to compute structural parameters for each park. Moreover, stem diameter and height structures of the trees were established. Principal component analysis was performed on the dendrometric variables and the first three components were correlated with climatic parameters. Results revealed significant differences between parks in most of the dendrometric and production parameters of shea trees. For all four parks, stem diameter and height structures present a Gaussian shape; for Sudanian parks, the curve has left dissymmetry. In regions with relatively high rainfall and relative humidity, shea trees developed large crowns, but produced few fruits whereas in the drier regions, the opposite trend was observed.

Tree cork caliber evolution in two consecutive cork extractions: trends and possible causes. Amaral Paulo, J., Tomé, M., Pereira, H. (*Technical University of Lisbon, Portugal; joanaap@isa.utl.pt; magatome@isa.utl.pt; hpereira@isa.utl.pt*).

The objective of the study was to research the influence of precipitation, tree variables, site characteristics, and debarking intensity on the evolution of cork caliber at the individual tree level. A mixed model approach was used in addition to partial least squares analysis. In 23 permanent plots two consecutive cork extraction operations were followed and cork samples were collected. The cork samples, from a total of 357 trees, covered growth years from 1984 to 2010. Since cork samples presented different numbers of years of growth, cork caliber was evaluated with the trough cork growth index (CGI). It was demonstrated that mean CGI from the two consecutive cork extractions, at plot level, decreased significantly in 16 out of the 23 plots for $\alpha = 0.05$. Results show that, although precipitation explained the larger part of the CGI evolution, tree diameter and stand density were also important variables. Debarking intensity was not as important an explanatory variable. The significance of site characteristics indicates that other variables are relevant, pointing out the need for further research.

Validation of five non-linear growth models for plantation-grown *Terminalia superba* in Ibadan, Nigeria. Awosusi, B., Oyeleye, B., Akinyemi, G., Ayodele, O. (*Forestry Research Institute of Nigeria; monisola.bola@yahoo.com; gbemioyebolarinwa@gmail.com; akinyemigab@yahoo.com; yehmmy2010@yahoo.com*).

Five non- linear mathematical models were developed and validated using growth data from one of the indigenous tree species in Nigeria (*Terminalia superba*). The selected models were: Malthusian, Gompertz, logistic, Von Bertalanffy, and Richard. These non-linear growth models were used to predict tree height using tree age as the independent variable. Methods of integrating the differential forms of the models used were also reviewed. Parameters of the models were estimated using the Marquardt iterative method of non-linear regression relating tree height to age. The data used were collected from the Forestry Research Institute of Nigeria, Ibadan, Nigeria. Formulas that provide good initial values of the parameters are specified. It was discovered that the logistic model showed very promising results. It fitted the data very well with a smaller relative standard error (0.4797) and higher R^2 (0.899). Results suggested that the models derived were statistically and biologically acceptable and could be satisfactorily used to predict tree height. The results also show the fundamental importance of growth models in forestry since any of the models here can be used to predict the tree growth and yield at a very early stage.

Climate change impact in the Uruguayan forest sector: an empirical evidences analysis. Bennadji, Z. (*Instituto Nacional de Investigaciónes Agropecuarias, Uruguay; zbennadji@tb.inia.org.uy*).

Since 1990, Uruguay has undertaken actions on climate change mitigation and adaptation, especially in the policy area. At the international level, Uruguay subscribes to the United Nations Framework Convention on Climate Change and complies with the preparation of periodic national-scale reports on greenhouse gas emissions. At the national level, an inter-ministerial committee

was created to follow up on the climate change impact on the main economic activities in the country. However, information for the forest sector was too scarce to allow any objective assessment of its exposure, sensitivity, and adaptive capacity to climate change. The objective of this work was to present empirical evidence as the basis of an analysis of climate change impacts in *Eucalyptus* and *Pinus* spp. plantations. The relationship between disturbance of forest tree phenology and growth, pest outbreaks, and extreme frost, drought, rainfall, and storm events from 1998 to 2012, and temperature and precipitation variations as the main climatic factors was investigated. The aim was creation of the first long-term data series in the country on climate change impacts on forest plantations. The need to consolidate this data series for use in modeling and prediction of climate change impacts on forest plantations at the local level and as a tool for practitioners is discussed.

'Carbon debt' – lost in the forest? Bentsen, N., Graudal, L., Madsen, P., Felbu, C. (*University of Copenhagen, Denmark; nb@ign.ku.dk*; *lgr@life.ku.dk; pam@ign.ku.dk; cf@gmail.com*).

The concept of 'carbon debt' and carbon payback time with reference to bioenergy and biofuels was probably launched by an article in Science in 2008. The concept is increasingly seen as an indicator of the sustainability of bioenergy supply chains. Particularly for forest bioenergy supply chains the time lapse between harvest and regrowth may be a significant factor for the modeled carbon debt. A meta-analysis of more than 250 model scenarios was conducted to evaluate the factors and assumptions determining carbon debts and payback time of forest bioenergy supply chains. Factors such as spatial and temporal scale, biome, origin of the wood resource, which fossil fuels are displaced, forest history, baseline scenario, accounting principle, and data background were included in the analysis. This paper discusses the evolution of the carbon debt concept, how different factors and assumptions influence the outcome of carbon debt studies, the reproducibility of carbon debt analyses, and the applicability of the concept as a measure of sustainability of forest bioenergy supply chains.

Assessing forest change across Canada using successive kNN-based maps of imputed forest inventory data. Bernier, P., Beaudoin, A., Guindon, L., Villemaire, P., Stinson, G. (*Canadian Forest Service, Canada; pbernier@rncan.gc.ca; abeaudoin@nrcan.gc.ca*, *lguindon@rncan.gc.ca; philipe.villemaire@rncan.gc.ca; graham.stinson@nrcan.gc.ca*).

The authors recently produced a suite of national maps of forest attributes for Canada at a resolution of 250 m for the 2001 base year. The non-parametric kNN approach was applied on a set of Canada-wide layers of predictive variables, most notably multi-spectral information from the MODIS sensor, as well as climate variables, topography, and land cover to impute National Forest Inventory baseline measurement data. Yearly maps at 250-m resolution were also produced showing severe forest disturbances, i.e., yearly areas affected by either harvesting or fire from 2001 to 2011. This paper presents updated maps of forest properties for 2011 and evaluates the extent to which changes between these maps and those for 2001 are able to capture the patterns of changes expected based on the yearly disturbance maps. Limitations of the approach as well as avenues for improvements of the kNN products are discussed.

Estimating stand heights and crown structure of subtropical broad-leaved forest using LiDAR data in Okinawa island, Japan. Binti Ahmad Zawawi, A. (*Kagoshima University, Japan; azitazawawi@gmail.com*), Shiba, M. (*Faculty of Agriculture, University of the Ryukyus, Japan; mshiba@agr.u-ryukyu.ac.jp*), Jemali, N. (*Kagoshima University, Japan; idiana0303@yahoo.com*).

The application of LiDAR to extract data at the single-tree level has long been recognized in providing valuable information about forest stands. Most studies involving crown detection and tree height estimation have focused on analysis of plantations, boreal forests, and temperate forests, and less study has been done in subtropical or tropical forests. This study presents an approach for estimating tree heights, stand density, and crown structure using LiDAR in the complex subtropical forest of Okinawa island in Japan. A digital canopy height model (DCHM) was derived from the LiDAR data for tree height estimation, and the watershed segmentation method was applied for individual crown delineation. Dominant tree canopy layers were estimated using multi-scale filtering and local maxima detection. Information on crown structure characteristics such as crown diameter and fractal dimension was also produced. The computed result was compared to field data and validated using IKONOS imagery over the forest area. The results of this study suggested that LiDAR data have huge capability to estimate tree height in subtropical forests, but were not sufficiently capable in the detection of small understory trees and in single-tree delineation. We found that LiDAR computation results underestimated the frequency of trees and overestimated the crown size.

Comparing alternatives for increasing sampling intensity in forest inventories. Blackard, J., Patterson, P. (*U.S. Forest Service, USA; jblackard@fs.fed.us; plpatterson@fs.fed.us*).

Each of the U.S. Forest Service's Forest Inventory and Analysis (FIA) regions has an occasional need to intensify the national sampling grid. A variety of methodologies exist within the various FIA regions and National Forest Systems regions for constructing plot intensifications, and there is no consensus on a national procedure The primary objectives of this paper were to identify various intensification methods being implemented by FIA or used by other groups, examine their advantages and disadvantages for establishing intensified plots within the existing FIA framework, and recommend a potential national FIA plot intensification procedure that might adequately address the needs for all FIA regions.

Paired catchment experimental methodology: a critique. Bren, L. (*University of Melbourne, Australia; lbren@ncable.net.au*), Nettles, J. (*Weyerhaeuser Company, USA; jami.nettles@weyerhaeuser.com*).

Paired catchment experiments have been around for almost a century. This paper examines how the technique has been used since the first project at Wagon Wheel Gap in Colorado, USA. Recent Australian work on the units and length of the calibration period showed that there is a rapid buildup of information in the first year of calibration and there may be little gain in long calibration periods. For this paper this hypothesis was tested in other countries using international data sets. Errors of measurement with this method were compared to alternative approaches such as plots or modeling. Although the presence of a "control" catchment is a great asset, the assumption of this control as a constant is examined given the long duration of some projects, and supplementary

techniques are suggested. This methodology, when scored against criteria of "experiments" taken from scientific literature, shows that the method is sound but could be improved by a more rigorous protocol of analysis. It is concluded that the technique does have a bright future and that a useful project would be a handbook of procedures, standards, and analytical procedures to facilitate the maximum information gain in such projects.

Estimating carbon storage in forest ecosystems in Poland based on data from the National Forest Inventory. Bronisz, K., Zasada, M. (*Warsaw University of Life Sciences, Poland; karol.bronisz@wl.sggw.pl; Michal.Zasada@wl.sggw.pl*), Neumann, M. (*University of Natural Resources and Life Sciences (BOKU), Austria; mathias.neumann@boku.ac.at*).

The objective of this study was to determine the amount of carbon sequestered by forest ecosystems in Poland based on data from the National Forest Inventory (NFI). The NFI is carried out on permanent plots across Poland on a 5-year cycle. The most recent cycle started in 2010. Detailed data about individual stands are provided regardless of ownership status and stand age. Empirical allometric formulas allow the determination of dry biomass of trees and their components on the basis of tree characteristics (height and diameter). Formulas for Scots pine and birch were based on data from Polish stands. To check the logical assumption of the additive character of those formulas, seemingly unrelated regression was used for their final determination. For other tree species, empirical formulas from different literature sources were applied. Amount of sequestered carbon was calculated basing on ratios suggested by the IPCC (50% of dry biomass). Results show that Polish forests are storing an increasing amount of carbon in the biomass of growing stock. However, the unbalanced age structure is cause for concern about the future status of the forest resource.

Global meta-analysis of forest bioenergy greenhouse gas emissions accounting studies (1991–2012). Buchholz, T. (*University of Vermont & Spatial Informatics Group LLC, USA; tbuchholz@sig-gis.com*), Gunn, J., Saah, D. (*Spatial Informatics Group, USA; jgunn@sig-nal.org; dsaah@sig-gis.com*).

The authors conducted a literature review of 59 studies (145 cases) that investigate greenhouse gas emissions (primarily CO_2) of forest-based bioenergy systems. The goal was to identify main drivers for calculating carbon debt across all studies using classification and regression tree analysis (CART). Studies with conclusions of carbon neutral over time (108 cases or 74% of all cases) determined that the carbon debt payback periods are highly influenced by (1) comparative fossil fuel type, (2) conversion technology, (3) feedstock source (including use of additional harvests or residues and plantation vs. natural forest management), (4) disturbance regimes (including wildfire, pest outbreaks, and climatic events), and (5) history of biomass infrastructure on existing landscapes. The use of dynamic as well as reference point baselines has been persistent throughout the period studied, and conclusions are fairly consistent across a variety of ecosystem types/climatic zones and regions. The scope of individual studies varies widely in analytical detail. For example, leakage was considered in only two studies, and product substitution in only 12 cases. Both pools are highly contentious and can have major impacts on overall results.

Measuring photosynthesis of beech seedlings with field imaging spectroscopy. Buddenbaum, H., Hill, J., Rock, G., Werner, W. (*Trier University, Germany; buddenbaum@uni-trier.de; hillj@uni-trier.de; rock@uni-trier.de; werner@uni-trier.de*).

Regional climate change is expected to cause more frequent occurrences of dryness stress in central Europe. To measure the effects on photosynthesis rate, we measured photosynthesis during the course of a day on one pot of fresh and one pot of dryness-stressed seedlings of beech (*Fagus sylvatica* L., 6 years old). At the same time, hyperspectral VNIR images of the plants were recorded from a 4-m high platform with about 1-mm spatial resolution (25 images in total). The photosynthesis time series was correlated with photochemical reflectance index (PRI) of the trees, calculated from the hyperspectral images. PRI was derived for all leaves and for sunlit leaves and shaded leaves separately. High correlations were found, especially for the shaded leaves. Differences of photosynthesis and PRI between fresh and dry plants were highly significant. PRI proved to be a good estimator for photosynthesis activity and for diurnal development. By transferring the results to mature beech stands in an airborne hyperspectral image and in a space-borne Chris-Proba image, routine measurements of photosynthesis and stress-induced reduction of photosynthesis activity from imaging spectroscopy satellites like the upcoming EnMAP will be tested.

Why aren't we making progress with predicting future forest dynamics? Bugmann, H. (*ETH Zurich, Switzerland; harald.bugmann@env.ethz.ch*).

The future development of forests is of utmost concern from not only a scientific, but also a societal, point of view, and appropriate adaptation measures in the face of climate change are thus hotly debated. Dynamic models have a long and seemingly highly successful history in forest science, but this author argues that their robustness is insufficient to serve as tools for deriving adaptive management approaches in the long term (i.e., beyond a few decades). The ability to model future long-term tree population dynamics is hindered by a number of factors, including the inadequate temporal and spatial scale of experimental approaches, the insufficient length of observational time series, and problems with the formulations of key ecological processes in models of forest dynamics. These factors and ways to handle them were reviewed, with the expectation that predictive understanding can be improved by the skillful combination of approaches and methods. In particular tree mortality was the focus as a process that (1) could lead to dramatic impacts in a world of global change, and (2) has attracted a lot of attention over the past years. The author concludes that although multiple challenges remain, there are promising options to pursue by combining empirical with dynamic modeling approaches.

Multi-scale spatial controls of understory vegetation in Douglas-fir – western hemlock forests of western Oregon, USA. Burton, J., Ganio, L., Puettmann, K. (*Oregon State University, USA; julia.burton@oregonstate.edu; lisa.ganio@oregonstate.edu;Klaus.puettmann@oregonstate.edu*).

Forest understory vegetation responds to numerous drivers that vary and interact over multiple spatial scales. This study examined how broad- to intermediate-scale variability in climate and insolation interacts with fine-scale plant-plant interactions and disturbances to affect spatial patterns of understory vegetation. Furthermore, the study examined how these relationships are mediated by traits of early- and late-seral vascular plant species. The authors used an operational-scale manipulative thinning

experiment replicated seven times in the Coast and Cascade ranges of western Oregon, USA. This paper focuses on patterns observed 6 years following thinning. Early-seral cover was related to interactions among broad-scale variation in climate, intermediate-scale variation in insolation, and fine-scale neighborhood interactions. Late-seral species cover was related primarily to fine-scale neighborhood interactions. Furthermore, cross-scale interactions partially explained patterns of spatial correlation among neighboring subplots for early-seral species but not late-seral species. The authors hypothesize that residual patterns of spatial autocorrelation were related to unmeasured environmental variables for early-seral species and historical conditions (i.e., pre-treatment stand composition and structure) for late-seral species. Results suggest responses of understory plants to overstory density management depend on cross-scale interactions among environmental drivers, neighborhood-scale interactions, and species traits.

Future demand for ecosystem services from terrestrial ecosystems from global power production scenarios to 2100: the role of forest biomass. Callesen, I. (*University of Copenhagen, Denmark; ica@ign.ku.dk*).

The world's electrical power production depends on the current energy infrastructure, and future investments in new power supply facilities using renewable and non-renewable energy sources. Continued growth in energy production in the 21st century will cause global environmental change. Along with climate change, global environmental change as an important driver will affect the environment and the economy in multiple ways that can be summarized as losses of biodiversity and changing ecosystem services, but with very diverse temporal and spatial impacts. Using a global growth model for power production that includes non-renewable and renewable energy sources, this paper investigates the potential role of forest biomass, and outlines the demands for ecosystem services imposed by global power production on ecosystems. Three scenarios called 'renewable,' 'efficiency,' and 'fossil' represent environmental impact scenarios for global power supply to 2100 as a simplified proxy of the global energy supply. The introduction of such future electrical power-mix scenarios in product life cycle assessment combines pressures from climate change, nitrogen enrichment, acidification, land use changes, and associated biodiversity impacts with the role of provisioning and regulating ecosystem services delivered by forests.

Influence of spacing regimes on the development of loblolly pine (*Pinus taeda* L.) in southern Brazil. Cardoso, D., Lacerda, A., Rosot, M., Garrastazu, M. (*EMBRAPA, Brazil; denise.cardoso@embrapa.br; andre.biscaia@embrapa.br; augusta_rosot@hotmail.com; marilice.garrastazu@embrapa.br*), Lima, R. (*Ideal Florestas, Brazil; renato.lima@idealflorestas.com.br*).

This paper reports the 24-year growth of *Pinus taeda* in Southern Brazil in response to five cultural regimes. Five initial spacing regimes (2.5 m × 1.2 m, 2.5 m × 2.0 m, 2.5 m × 2.8 m, 2.5 m × 3.6 m, and 2.5 m × 4.4 m) combined with cultural procedures generally used in commercial stands were studied. Dendrometric variables analyzed include DBH, average and dominant height, site index (SI), basal area, volume per tree and per hectare, and assortment volume. The results indicate a final lower average DBH in denser spacing regimes but no significant difference in relation to volume per hectare and basal area at the end of the 24-year cycle. It is possible to obtain the same volume per hectare, on average 385.7 m^3/ha, at the age of harvesting by combining different initial spacings with thinning intensities. The mean annual increment (MAI) has a positive correlation with initial spacing; the densest spacing had a MAI 45% higher than the widest treatment. The results provide managers with long-term data that can be used in forest management planning, for example by allowing companies to adjust their operations depending on the costs of planting, maintenance, and other cultural treatments.

The afforestation present in the squares of the city of Ponta Grossa, Paraná, Brazil. Carvalho, S., Dos Santos, Z. (*State University of Ponta Grossa, Brazil; silviameri@brturbo.com.br; zihngara@hotmail.com*).

Open spaces, especially parks, are an essential element of the urban environment because they are meant to provide the chance for leisure and increase the quality of life for the population. The afforestation in 83 squares in the city of Ponta Grossa, in southern Brazil, was evaluated quantitatively and qualitatively. The size and condition of 2 369 trees from 69 species and 33 families were also evaluated. It was found that 65.86% of the species are exotic. The most frequent species was *Ligustrum lucidum* (22.08%), a percentage considered high. Most of the trees, 57.83%, are in good condition, 36.81% in satisfactory condition, 4.1% in poor condition, and 1.3% dead. Regarding size 48.8% are large trees, 23.17% are medium sized, 21.82% are small, and 6.21% are seedlings. Regarding the Density Index Arborea (IDA) for each square, it was observed that of the 71 squares with vegetation, only 33.8% are above 1, that is, have one or more trees for every 100 m^2. The afforestation of city squares was found to be heterogeneous, as there are squares with many trees, and some without any.

Environmental valuation of trees in the city of Ponta Grossa, Paraná, Brazil, by emergy analysis. Carvalho, S., Carneiro, D. (*State University of Ponta Grossa, Brazil; silviameri@brturbo.com.br; dacriscar@hotmail.com*).

Emergy is a universal measure of the real wealth of the work of nature and society made on a common basis. In this sense, emergy analysis is presented as a methodology that recognizes and measures the universal hierarchy of power, in this case, the urban forests of the city of Ponta Grossa, in southern Brazil. A total of 2 379 trees on the streets and in the city squares of downtown Ponta Grossa were recorded and measured. Their respective values, in terms of components of the economy (labor and expenses related to afforestation) and from the environment (average local rainfall, soil nutrients, and biomass of the analyzed trees) were estimated. Thus, the emergy value per tree was obtained. The average value 5.54E +15 seJ per tree was found. Use of the *emdollar*, which is obtained from the emergy analysis of the local economy, is recommended. Therefore, the average value of $1 240.00 per tree was obtained, which takes into account the average contribution per tree to the economy and to the environment. With the emergy environmental valuation, it can be seen that the work of nature is recognized, and that environmental and urban planning—in this case, urban forestry in Ponta Grossa—can be better conducted.

Blue carbon of selected natural and plantation stands of mangrove forests in the Philippines. Castillo, J. (*Ecosystem Research and Development Bureau, the Philippines; allan536@yahoo.com*).

This study estimated the carbon stored in the biomass and sediment in selected natural and plantation stands of mangrove forests in the Philippines. For natural stands, the total carbon stock in biomass and sediment combined was 262.66 metric tons C/ha, on

average, and ranged from 178.41 to 369.70 metric tons C/ha. The carbon sequestered during the 2 years of the study based on biomass accumulation in the four natural mangrove stands studied was 3.83 t C/ha/yr, on average, and ranged from 1.90 to 5 t C/ha/year. For mangrove plantations, all of the plantations studied were *Rhizophora* plantations, mostly mixed *Rhizophora apiculata* and *Rhizophora mucronata* stands with trees 12–27 yr old or 18.5 yr on average. The combined carbon held by the biomass and upper 30 cm of sediment in the mangrove plantations was on average 190.59 metric tons C/ha and ranged from 117.56 to 262.45 metric tons C/ha. The yearly rate of carbon accumulation in the biomass of the four mangrove plantations based on carbon stock and plantation age was 4.01 t C/ha on the average and ranged from 2.75 to 5.15 t C/ha/year. The study demonstrated the potential of mangrove forests in the Philippines, both in natural stands and in plantations, as an option for climate change mitigation.

National assessment of non-timber forest products: prospects for improving the reporting of volumes and values of these products. Chamberlain, J., Patel-Weynand, T., Haan, T. (*U.S. Forest Service, USA; jchamberlain@fs.fed.us; tpatelweynand@fs.fed.us; tjhaan@fs.fed.us*).

Non-timber forest products (NTFPs) have been significant contributors to the forest products industry in the United States (Chamberlain *et al*., 1998) since this country was established. The United States has been a major supplier of herbal forest products used for their medicinal value, though the economic contribution has not been fully accounted for in valuing the forest products industry. For more than 60 years, the U.S. Forest Service has been tracking wood production through the timber products output (TPO) assessments and can estimate production by product and county of origin. In addition, the Forest Service's Forest Inventory and Analysis (FIA) group can estimate growing stock, tree removals, and forest condition and age, as well as land ownership patterns. These estimates provide a comprehensive assessment of the trees and timber products that make up the forests and related industries. But that assessment capability is lacking for the non-tree resources or the non-timber products that are harvested from the forests. Through a series of interviews, conversations, a workshop, and reviews of policies, regulations, and literature, the Forest Service has undertaken a national assessment to examine the potential and pitfalls of improving the reporting of NTFPs. This presentation examined the status of non-timber forest products and identified gaps in the knowledge and ways to improve conservation, management, and reporting of these valuable products.

Assessment of aboveground biomass and soil carbon storage of the fallow forests after swidden cultivation in the Bago Mountains, Myanmar. Chan, N. (*Kyoto University, Japan; nchan08@gmail.com*), Takeda, S. (Kyoto University*, Japan; takeda@asafas.kyoto-u.ac.jp*), Suzuki, R. (*Kyoto Gakuen University, Japan; suzuki@kyotogakuen.ac.jp*), Yamamoto, S. (*Kagoshima University, Japan; sotayama@cpi.kagoshima-u.ac.jp*).

This study was conducted to assess the aboveground biomass (AGB) accumulation and soil carbon (SC) storage in the swidden cultivated fallows of the Bago Mountains, Myanmar, by using a chronosequential approach. The 34 sample plots were randomly set up in 1-, 5-, 10-, 15-, 20-, 25-, and 30-year-old fallows, as well as in nearby old forests. The AGB in the fallows was estimated by the allometries established through destructive sampling. Similarly, the 213 soil samples were taken at 0–10 cm, 10–20 cm and 20–30 cm layers from the fallows to analyze soil carbon storage by using an NC analyzer. The average total AGB (including trees, bamboo, understory vegetation, and vines) in 1-, 5-, 10-, 15-, 20-, 25-, 30-year-old fallows and in the nearby old forests were 13.91, 31.31, 52.96, 66.52, 103.12, 88.45, 92.42 and112.48 Mg/ha, respectively. The average total SC was 23.31, 18.31, and 15.01 Mg ha^{-1} in the 0–10 cm, 10–20 cm and 20–30 cm layer, respectively. The results show that the AGB increased with fallow age, with the largest contribution by bamboo biomass in the fallows. However, the average SC accumulation in the fallows was about 58.14 Mg/ha with the fluctuation trend along the fallow age.

The contribution of historical vegetational database recovery to the study of forest biodiversity in Trentino (Italy). Ciolli, M. (*University of Trento, Italy; Marco.Ciolli@unitn.it*), La Porta, N., Zottele, F. (*Edmund Mach Foundation, Italy; nicola.laporta@fmach.it; fabio.zottele@fmach.it*), Geri, F. (*University of Trento, Italy; geri.francesco@gmail.com*).

Multi-temporal biodiversity data for a forest ecosystem can provide useful information about the evolution of biodiversity in that area. The Edmund Mach Foundation owns an archive used to determine the main Schmid's vegetational belts in the Trento province of Italy. The archive contains data collected over 20 years, from the 1970s until the 1990s. The database was developed with tools and technologies that are now obsolete, making it unusable. As part of the FORCING project, a comprehensive process of database recovery was carried out: an analysis of the data structure was performed to reverse-engineer the database structure, and missing data were digitized from historical maps and other preserved documents. All the maps of the 16 forest districts and the related 8,000 detected transects have been georeferenced to geographically enable the whole database and to evaluate the possibility of performing comparative samplings on up-to-date data sets. Raw data for vegetation (about 200,000 specific identifications including frequency indices) remain an important and irreplaceable source of information not only for their historical value, but also for many other applications. Provided here are examples of how this kind of data can be used in different multitemporal comparisons. The potential and the limits of the specific data set and of the historical data base in general are highlighted.

An historically consistent and broadly applicable MRV system based on LiDAR sampling and Landsat time-series. Cohen, W., Andersen, H., Healey, S. Moisen, G., Schroeder, T., Woodall, C., Domke, G. (*U.S. Forest Service, USA; wcohen@fs.fed.us; handersen@fs.fed.us; seanhealey@fs.fed.us; gmoisen@fs.fed.us; tschroeder@fs.fed.us; cwoodall@fs.fed.us; gmdomke@fs.fed.us*), Yang, Z. (*Oregon State University, USA; zhiqiang.yang@oregonstate.edu*), Stehman, S. (*State University of New York, USA; svstehma@syr.edu*), Kennedy, R., Woodcock, C., Zhu, Z. (*Boston University, USA; kennedyr@bu.edu*), *curtis@bu.edu; zhuzhe@bu.edu*), Vogelmann, J., Steinwand, D. (*U.S. Geological Survey, USA; vogel@usgs.gov*), *steinwand@usgs.gov*), Huang, C. (*University of Maryland, USA; cqhuang@umd.edu*).

The authors are developing a REDD+ MRV system that tests different biomass estimation frameworks and components. Design-based inference from a costly field plot network was compared to sampling with LiDAR strips and a smaller set of plots in combination with Landsat for disturbance monitoring. Biomass estimation uncertainties associated with these different data sets

in a design-based inference framework was examined. The authors are also testing estimators that rely primarily on Landsat within a model-based inference framework. Contributions from Landsat are current (e.g., 2013) spectral response and metrics describing disturbance history derived from a time-series leading up to the current date. An advantage of the model-based framework is its extension back in time (e.g., to 1990) using a consistent approach based on disturbance history as an indicator of biomass density. This requires use of the older, MSS archive to be fully effective in estimating biomass for the 1990 baseline. The United States, though not a REDD country, is party to the UNFCCC and has a need for similar NGHGI baseline information. The various components of the authors' MRV system will be tested in the United States, where sufficient data are available for parsing the uncertainty contributions of the several system components being tested.

Longitudinal and radial variation of the wood density in an unmanaged stand of *Araucaria angustifolia.* Curto, R. (*Federal University of Paraná, Brazil; rafaellacurto@yahoo.com.br*), Mattos, P., Muñoz-Braz, E. (*EMBRAPA, Brazil; patricia.mattos@embrapa.br; evaldo.braz@embrapa.br*), Pellico Netto, S. (*Federal University of Paraná, Brazil; sylviopelliconetto@gmail.com*), Zachow, R. (*Brazilian Forest Service, Brazil; randolfzachow@hotmail.com*).

The objective was to evaluate the wood density variation of *Araucaria angustifolia* in a 66-year-old stand. Thinning was carried out only between 1970 and 1980, without records after this period. Nine trees in three diameter classes (suppressed, intermediate, and dominant) were selected randomly. Wood density was determined at six different heights (0, 20, 40, 60, 80, and 100% of commercial stem) and in the radial direction in five samples, for each height. The average wood density along the stem presented no statistical difference among the three diameter classes, when comparing similar height percentages. Average wood density differed significantly, decreasing in the longitudinal direction. However, it was observed that the average wood density at 60% was greater than at 40%, suggesting that this is an effect related to the thinning carried out in the past. Management of *Araucaria angustifolia* stands, aiming at balanced tree competition with periodic thinning, will enable the production of wood with lower density variability, and will reduce problems in mechanical processing.

Forest carbon storage and tree biomass dynamics under the Natural Forest Protection Project in the northeastern forest region of China. Dai, L. (*Chinese Academy of Sciences, China; lmdai@iae.ac.cn*).

The role of forest ecosystem carbon storage and biomass dynamics under the Natural Forest Protection Project (NFPP) in China's forests remains unknown. This study collected forest inventory data and used plot databases in northeastern China to calculate forest ecosystem carbon storage in the region. Results showed that under the NFPP trees in the northeastern region functioned as a carbon sink from 1998 to 2008, with a carbon storage accumulation of 6.3 Tg C/yr. Most of the C storage was in natural forests (5.1 Tg C/yr), but simultaneously, planted forests also acted as a carbon sink, with accumulation of 1.2 Tg C/yr. In addition, the existing total ecosystem carbon storage in the region was 4 603.8 Tg C, of which 4 393.3 Tg C was stored in natural forests and 210.5 Tg C in planted forests. Tree carbon density of natural forests was also higher than in planted forests. Soil contained the largest carbon storage and contributed 69.5–77.8% of total carbon storage. Tree and forest floor carbon pools accounted for 16.3–23.0% and 5.0–6.5%, respectively. Understory pools, which ranged from 1.9 to 42.9 Tg C, accounted for only 0.9% of total carbon storage under the NFPP in northeastern China.

Using inventory-based tree-ring data as a proxy for historical climate: investigating the Pacific decadal oscillation and teleconnections. DeRose, R. (*U.S. Forest Service, USA; rjderose@gmail.com*), Wang, S. (*Utah State University, USA; simon.wang@usu.edu*), Shaw, J. (*U.S. Forest Service, USA; jdshaw@fs.fed.us*).

In 2009, the Interior West Forest Inventory and Analysis (FIA) program of the U.S. Forest Service started to archive approximately 11 000 increment cores collected in the Interior West states during the periodic inventories of the 1980s and 1990s. The two primary goals for use of the data were to provide a plot-linked database of radial growth to be used for growth model development and other biometric analyses, and to develop a gridded dendroecological database that could be used to analyze regional patterns of climate, disturbance, and other ecosystem-scale processes. Early analysis related to the latter goal showed that the finely gridded data could be used to map past climatic patterns with more detail than is possible using traditional chronologies. FIA-based Douglas-fir and pinyon pine chronologies showed high temporal coherence with previously published tree-ring chronologies, and the spatial and temporal coherence between the FIA data and water year precipitation was strong. FIA data also captured the El Niño-Southern Oscillation (ENSO) dipole and revealed considerable latitudinal fluctuation over the past three centuries. Finally, the FIA data confirmed the coupling between wet/dry cycles and Pacific decadal variability known to exist for the Intermountain West. These results highlight the further potential for high-spatial-resolution climate proxy data sets for the western United States.

Adaptability of ecosystem-based management to climate-induced increase in fire frequency and growth anomalies in an eastern Canadian boreal forest. Dhital, N., Raulier, F. (*Laval University, Canada; narayan-prasad.dhital.1@ulaval.ca; Frederic.Raulier@sbf.ulaval.ca*), Bernier, P. (*Natural Resources Canada; pbernier@nrcan-rncan.gc.ca*), Lapoint-Garant, M. (*Université du Québec à Montréal, Canada; lapointe-garant.marie-pierre@courrier.uqam.ca*), Bergeron, Y. (*Université du Québec en Abitibi-Témiscamingue, Canada; yves.bergeron@uqat.ca*), Rodriguez, G. (*Laval University, Canada; gereroba@gmail.com*).

Adaptability of ecosystem-based management (EBM) to the potential impact of climate change was evaluated with attention to the role of climate on forest growth and fire regime in a boreal forest of eastern Canada. A climate-sensitive growth index model was calibrated for three commercial species (black spruce (*Picea mariana* (Mill) B.S.P.), jack pine (*Pinus banksiana* Lamb.), and trembling aspen (*Populus tremuloides* Michx.). The model was used to project the evolution of merchantable volume over time under conventional sustained yield timber production and EBM under two climate scenarios. Current burn rate and burn rates under future climate scenarios were also considered. Under the projected climate scenarios, the periodic timber supply responded with long-term reduction by up to 79%. An interaction between the response of growth and fire to the projected climate scenarios was also revealed. EBM emerged a better management strategy in the context of projected climate. It maintained a higher mean standing inventory age, a lower proportion of area under younger age, and a higher level of periodic timber supply. However, further adaptation strategies are needed to deal with the projected climate scenarios and their potential impact on growth and disturbance dynamics.

Methodological proposal for the assessment of the sustainability of *Eucalyptus* spp. plantations in Spain. Diaz Balteiro, L. (*Technical University of Madrid, Spain; luis.diaz.balteiro@upm.es*), Alfranca, O. (*Polytechnic University of Catalonia, Spain; oscar.alfranca@upc.edu*), Bertomeu, M., Gimenez, J. (*University of Extremadura, Spain; bertomeu@unex.es; jcfernan@unex.es*), Romero, C. (*Technical University of Madrid, Spain; carlos.romero@upm.es*).

This paper shows a method based upon multi-criteria analysis for deriving a ranking of eucalyptus plantations in terms of sustainability. Sustainability was characterized by considering 11 indicators of different types (e.g., ecological, economic, social). These indicators were applied to 30 private forest systems (plantations) in which stands are dominated by *Eucalyptus* spp. but contain other species. In this way, a 30 × 11 pay-off matrix was initially obtained. After the elements of the matrix were normalized, and one indicator had been dropped due to correlation issues, several models based on compromise programming and goal programming were formulated. By solving these models a ranking of the 30 forest systems was obtained. In addition, possible links between the certification of the plantations and their sustainability were established. The analysis could be extended by introducing the preferences of different stakeholders, which in practical terms would involve attaching different preferential weights to the indicators used.

Exploring options for the estimation of forest carbon stocks from 1990 to the present using the national forest inventory of the United States. Domke, G., Woodall, C., McRoberts, R., Walters, B. (*U.S. Forest Service, USA; gmdomke@fs.fed.us, cwoodall@fs.fed.us, rmcroberts@fs.fed.us, bfwalters@fs.fed.us*).

The Forest Inventory and Analysis (FIA) program of the U.S. Forest Service is responsible for compiling estimates of forest carbon stocks and stock changes as part of the National Greenhouse Gas Inventory report produced annually by the U.S. Environmental Protection Agency. In 1999, the FIA program made a transition from state-by-state periodic inventories largely tailored to regional requirements to nationally consistent, annual inventories designed for large-scale strategic requirements. Lack of measurements on all forest land during the periodic inventories, along with plot access difficulties and misidentification of forest plots as nonforest due to poor aerial imagery, has resulted in missing data throughout the FIA database. These data gaps contribute to differences in estimates of forest C stocks and stock change due to the procedural transition from periodic to annual inventories. This study builds on recent work examining strategies to compensate for nonresponse in annual inventories by evaluating imputation and model-based approaches to update forest carbon data throughout the periodic inventories using plots measured previously in the periodic inventories. The precision and uncertainty of annual estimates throughout the periodic inventories will be evaluated for each updating approach and forest carbon stocks and stock changes obtained using current methods will be compared with estimates obtained from approaches proposed in this study.

The effect of varying estimation procedures on downed dead wood carbon stock estimates using the national forest inventory of the United States. Domke, G. (*U.S. Forest Service, USA; gmdomke@fs.fed.us*), Harmon, M. (*Oregon State University, USA; mark.harmon@oregonstate.edu*), Woodall, C. (*U.S. Forest Service, USA; cwoodall@fs.fed.us*), Fasth, B. (*Oregon State University, USA; becky.fasth@oregonstate.edu*), Walters, B. (*U.S. Forest Service, USA; bfwalters@fs.fed.us*).

Over the last several decades, downed dead wood (DDW) in forests has emerged as an important component in ecosystem structure and function. Renewed interest in utilizing forest biomass for energy has further elevated the profile of DDW and the contribution of this component to the carbon cycle. In the United States, the national forest inventory conducted by the U.S. Forest Service, Forest Inventory and Analysis (FIA) program has been consistently measuring DDW since 2001. Recently, modeled estimates of DDW carbon stocks were replaced in the FIA inventory with estimates developed from field measurements. The nationally consistent FIA inventory data were used as a mechanism to evaluate alternative volume models, density reduction factors, and carbon concentration constants used to estimate DDW carbon. The results illustrate the complexities in measuring and modeling DDW dynamics in forest ecosystems and estimating DDW biomass and carbon across multiple spatial scales. Using FIA data to compare alternative estimation methods and inputs was a convenient mechanism for assessing the implications of emerging research on DDW and should prove useful in the evaluation of other forest and tree attributes.

Effects of different harvesting scenarios in a Brazilian eucalyptus catchment. Faria, V.G., Garcia, L., Ferraz, S., Rodrigues, C.B., Lima, W.P. (*University of São Paulo, Brazil; viniciusgf@usp.br; larajangada@gmail.com; silvio.ferraz@usp.br; cabreuva@gmail.com; wplima@usp.br*), Mingoti, R. (*EMBRAPA, Brazil; rafael.mingoti@embrapa.br*).

Eucalyptus plantations cover more than 5 million ha in Brazil and have an important role in the economy, environment, and society of that nation. This paper focused on the environmental issues concerning forestry logging practices, especially those regarding soil conservation. For this purpose the physics-based hydrological model, gridded surface subsurface hydrologic analysis (GSSHA), will be applied to an experimental catchment (85 ha) located in southeastern Brazil. GSSHA will be run with a 2011 year-round data set, which was both collected on site and based on literature, taking into account the main hydrological processes and soil erosion-sediment routing. Methods for calibrating and validating the model will also be discussed. Simulations with long-term scenarios will consider different harvesting intensities (0%, 25%, 50%, and 100% of clearcutting) and will be performed by modifications on land-use input parameters. The event-based variables considered for statistical purposes will be (1) surface erosion (m^3), (2) sediment wash-load discharge (m^3), maximum rate of wash-load discharge (m^3/s), and (4) stream peak discharge (m^3/s). With this paper the authors expect to demonstrate the importance of patch cutting methods to ensure sustainable forest management and conservation of land resources in a Brazilian Eucalyptus production site.

Combining LiDAR structure and ecology data in predictive ecosystem mapping models for improved estimates of landscape-scale forest carbon. Fedrigo, M. (*University of Melbourne, Australia; mel.fed@gmail.com*), Roxburgh, S. (*Commonwealth Scientific and Industrial Research Organization (CSIRO, Australia; Stephen.Roxburgh@csiro.au*), Bennett, L., Kasel, S., Nitschke, C. (*University of Melbourne, Australia; ltb@unimelb.edu.au, skasel@unimelb.edu.au, craign@unimelb.edu.au*).

Predictive ecosystem mapping models (PEMMs) can identify the potential spatial distribution of individual species or larger forest types based on input variables from a variety of sources. The two most common PEMMs are those solely based on field ecology

and those using remote sensing and GIS data, but few PEMMs incorporate significant elements of both data types. PEMMs are increasingly being developed for landscape-scale forest management and monitoring due to the availability of landscape-level data sets, the improvement in landscape-scale data acquisition, and the ability to improve these models as new data become available. In this study, a PEMM was developed that uses both airborne LiDAR data, which characterised forest structure, and ecological plot data to quantify the geographic extent and biomass/C content of cool temperate rain forest across the Central Highlands region of south-eastern Victoria, Australia. The authors demonstrate how field-based measures of this forest type combined with LiDAR structural information can give better predictions of spatial distribution and biomass and carbon content at the landscape scale within this region. They also demonstrate how this PEMM approach can be used for determining the impact of forest harvesting and management on the distribution and structure of cool temperate rain forest.

Western Africa tropical Sudanian riparian forest contribution to ecosystem carbon balance performance in Togo. Folega, F. (*Beijing Forestry University, China; ffolega@yahoo.fr*), Wala, K. (*Université de Lomé, Togo; kpwala75@yahoo.fr*), Zhang, C. (*Beijing Forestry University, China; zcy_0520@163.com*), Batawila, K. (*Université de Lomé, Togo; batawilakomlan@yahoo.com*), Zhao, X. (*Beijing Forestry University, China; bfuz@163.com*), Akpagana, K. (*Université de Lomé, Togo; koffi2100@gmail.com*).

Research was conducted to determine available biomass in a riparian ecosystem in the Sudanian area of northern Togo by analyzing land cover types and estimating biomass productivity of vegetation on the site. Diameter and height of trees of DBH ≥10 cm in rectangular 500-m^2 plots located adjacent to rivers were recorded. An allometric equation was used to compute aboveground and belowground biomass. Landsat ETM+ imagery was then used to assess the major land cover types, and net primary productivity (NPP) was calculated. Across the 5.4 ha sampled, total biomass density was 196.77 metric tons/ha. Tree species such as *Daniellia oliveri* contribute much of the total biomass. Four major land cover types (permanent woody vegetation, fallows-farmlands, barren land, and permanent moist areas) were defined. The NPP for the investigated site was estimated at $8.99x10^9$±11 738.13 g C/m^2/yr, and the map of NPP distribution matches well with the land cover map. This research could be useful for researchers, planners, and administrators within the clean development mechanism (CDM) framework.

Random forests and stochastic gradient boosting for predicting tree canopy cover: comparing tuning processes and model performance. Freeman, E., Moisen, G., Coulston, J., Wilson, B. (*U.S. Forest Service, USA; eafreeman@fs.fed.us, gmoisen@fs.fed.us*), *jcoulston@fs.fed.us; barrywilson@fs.fed.us*).

Random forests (RF) and stochastic gradient boosting (SGB), both involving an ensemble of classification and regression trees, are compared for modeling tree canopy cover for the 2011 National Land Cover Database (NLCD). The objectives of this study were twofold. First, sensitivity of RF and SGB to choices in tuning parameters was explored. Second, performance of the two final models was compared by assessing the importance of, and interaction between, predictor variables, the global accuracy metrics derived from an independent test set, and the visual quality of the resultant maps of tree canopy cover. Examination of relative variable importance elucidated the differences in how RF and SGB make use of correlated predictor variables. SGB had a tendency to concentrate variable importance in fewer variables, whereas RF tended to spread importance out amongst more variables. The predictive accuracy of RF and SGB was remarkably similar on all four of the pilot regions, by all the accuracy measures examined. RF is simpler to implement than SGB, as RF both has fewer parameters needing tuning, and also was less sensitive to these parameters.

Small-area estimation of forest attributes within fire boundaries. Frescino, T., Moisen, G. (*U.S. Forest Service, USA; tfrescino@fs.fed.us; gmoisen@fs.fed.us*), Adachi, K., Breidt, J. (*Colorado State University, USA; kristenkadachi@gmail.com; jbreidt@stat.colostate.edu*).

Wildfires are gaining more attention every year as they burn more frequently, more intensely, and across larger landscapes. Generating timely estimates of forest resources within fire perimeters is important for land managers to quickly determine the impact of fires on U.S. forests. The U.S. Forest Service's Forest Inventory and Analysis (FIA) program needs tools to produce these estimates in a timely matter. Small-area estimation methods were recently developed and applied to previous wildfires in Colorado. This paper illustrates how these methods were assimilated into an automated R-based programming environment, FIESTA, to produce estimates of forest resources affected by a specified fire perimeter. This small-area estimation approach uses a modified composite estimator, which is a weighted average of two estimators: a synthetic estimator built from model-based predictions, and a direct estimator built from the FIA plot data that fall within the small area. The synthetic estimator is generated from FIA sample data and Landsat geospatial layers (www.landfire.gov) that fall within a larger area encompassing the small area, delineated by the Forest Service EcoMap Subsections.

Austrian forest biodiversity index (AFBI) – concept and results. Geburek, T., Richard, B., Michael, E., Frank, G., Hauk, E., Liebmann, S., Neumann, M., Starlinger, F. (*Federal Research Centre for Forests, Austria; thomas.geburek@bfw.gv.at; richard.buechsenmacher@bfw.gv.at*), *michael.englisch@bfw.gv.at georg.frank@bfw.gv.at; elmar.hauk@bfw.gv.at; sylvia.liebmann@bfw.gv.at; markus.neumann@bfw.gv.at; franz.starlinger@bfw.gv.at*).

Forest biodiversity cannot be measured and monitored directly. Indicators referring to different biodiversity levels (genes, species, ecosystems) are needed to tackle this task. In addition, indicators must provide an appropriate basis for tangible goals in forest and environmental policy. In this paper a single aggregated measure is proposed: the Austrian forest biodiversity index (AFBI). This index is composed of different indicators that are weighted depending on their putative significance for the maintenance of forest species richness and genetic diversity. The AFBI consists of nine state and four response indicators. Selection of state indicators was based on the general hypothesis that forests which mimic natural conditions or are characterized by structural elements of old-growth forests maintain a high number of forest-dependent species and a high genetic richness therein. Among the response indicators, the establishment of natural forest reserves and of genetic reserve forests, and utilization of seed stands and seed orchards were considered the most relevant. Each indicator is referenced and the sum of all weighted indicator measures is rescaled as a total score that may vary from 0 to 100, so that the AFBI is simple to communicate and straightforward to apply. Data of the AFBI are presented and discussed.

Local and general above-stump biomass functions for loblolly pine and slash pine trees. Gonzalez-Benecke, C., Gezan, S. (*University of Florida, USA; cgonzabe@ufl.edu; sgezan@ufl.edu*), Albaugh, T., Burkhart, H. (*Virginia Polytechnic Institute and State Universityt, USA; tim_albaugh@vt.edu; burkhart@vt.edu*), Jokela, E. (*University of Florida, USA; ejokela@ufl.edu*), Maier, C. (*U.S. Forest Service, USA; cmaier@fs.fed.us*), Martin, T. (*University of Florida, USA; tamartin@ufl.edu*), Rubilar, R. (*Universidad de Concepción, Chile; rrubilar@ncsfnc.cfr.ncsu.edu*), Samuelson, L. (*Auburn University, USA; samuelj@auburn.edu*).

Currently, there is an increasing interest in estimating biomass for loblolly pine and slash pine trees, the two most commercially important tree species of the southeastern United States. Most of the available individual-tree allometric models are local, relying on stem diameter outside bark at breast height and, in some cases, total tree height. Only a few include stand age or other covariates. In this research, a large data set collected from five forestry research institutions in the southeastern United States, consisting of biomass measurements from 744 loblolly pine and 259 slash pine trees, was used to develop a set of individual-tree equations to estimate above-stump biomass of all tree components (foliage, bole, bark, and branch). Specific equations that can be used in the physiological process-based model 3PG were also developed. Local and general models are presented for each tree attribute. Local models included DBH or DBH and height as predicting variables. General models included stand-level parameters such as age, quadratic mean diameter, basal area, and stand density. The inclusion of stand parameters greatly improved the accuracy of predictions of above-stump biomass. The first set of local and general allometric equations are reported for both species. The models can be applied to trees growing over a large geographical area and across a wide range of ages and stand characteristics.

Wood volume estimation for eucalyptus plantations using ALS metrics and stand age. Görgens, E., Silva, A., Oliveira, J., Rodriguez, L. (*University of São Paulo, Brazil; gorgens@usp.br; andregracioso@gmail.com; juliannecoliveira@usp.br; lcr@usp.br*).

This study compared traditional and ALS-based yield models adjusted to estimate stand volume in fast-growing eucalyptus plantations in Brazil. The plantation stands are located in the state of São Paulo and are managed to produce logs for pulp mills. The LiDAR campaign occurred at the end of the rainy season, and covered stands ranging from 2 to 8 years old. The field data came from one hundred and twelve 400-m^2 circular plots measured during the same flight mission period. The traditional model estimated volume as a function of age, site index, and basal area; the alternative estimated volume as a function of age, metric cubic mean height, and metric 95th percentile. The plots were randomly divided into training (60%) and validation (40%) data. The comparison was guided by an evaluation of the RMSE and a graphical analysis of the residuals. The model based on LiDAR metrics resulted in RMSE of 32.5 m³/ha (13.3%) and the traditional in RMSE of 11.2 m/ha (5%). The lower performance of the model with ALS metrics is due to the larger variance of the cubic mean height metric. The work shows good potential for large-scale ALS forest monitoring.

Application of the carbon budget model to estimate Europe's current and future forest carbon sequestration. Grassi, G., Pilli, R. (*Joint Research Centre Institute for Environment and Sustainability, Italy; giacomo.grassi@jrc.ec.europa.eu; roberto.pilli@ext.jrc.ec.europa.eu*), Kurz, W. (*Natural Resources Canada; wkurz@nrcan.gc.ca*).

The estimation of forest carbon sequestration potential in Europe is a challenging task due to complex and varying silvicultural systems, including uneven-aged forest management, and incomplete inventory data time-series. In this study, the carbon budget model of the Canadian Forest Sector (CBM-CFS3) was used to develop estimates of carbon stock changes in various forest pools (including links with the harvested wood product pool, HWP, in line with the new IPCC methodological guidance) in 25 EU countries. Estimates cover the historical period (since 2000, including major past natural disturbances) and simulations of different harvest rate scenarios to 2030. A number of methodological challenges required modifications to the default model implementation, that is, to include uneven-aged forest management and to reconstruct past carbon dynamics. This study demonstrated the utility of the CBM-CFS3 for country-scale estimation of past and future carbon sequestration from forests, potentially supporting the verification of greenhouse gas inventories and the design and monitoring of forest and climate-related policies.

Stand canopy cover prediction from individual tree measurements: stocking, crown width, and overlap functions. Gray, A. (*U.S. Forest Service, USA; agray01@fs.fed.us*), McIntosh, A. (*University of Alberta, Canada; amcintos@ualberta.ca*), Garman, S. (*U.S. Geological Survey, USA; slgarman@usgs.gov*).

The goals for a wide range of forest management objectives are often stated in terms of the amount and layering of canopy cover. However, measuring canopy cover is labor intensive and different techniques provide widely different estimates. Several approaches have been developed to predict cover from common tree- or stand-level density attributes, with varying results. This study used line-intercept measured tree cover from 1 800 U.S. Forest Service, Forest Inventory and Analysis (FIA) plots across the state of Oregon to build predictive models from estimates of tree stocking, crown width, and other stand attributes (e.g., mean diameter, stand height, stand density index). A variety of adjustments were applied to adjust for tree social status and account for tree crown overlap. Stocking was a better predictor of cover than was crown width, although much of the error in the latter was due to estimates of crown overlap. The random crown overlap function that is standard in the Forest Vegetation Simulator (FVS) resulted in biased predictions in mesic forest types, but not in dry forest types. New model predictions based on stocking for mesic forest types were within 15% of measured cover for >82% of the observations. Although there are some additional options for improving estimated cover from tree and stand attributes, ground-based measurements will probably be required for precise estimates.

Novel automated terrestrial LiDAR sensor decreases forest measurement uncertainties when used in a multi-method approach. Griebel, A., Arndt, S., Bennett, L., Lane, P. (*University of Melbourne, Australia; agriebel@student.unimelb.edu.au; sarndt@unimelb.edu.au;ltb@unimelb.edu.au; patrickl@unimelb.edu.au*), Culvenor, D. (*Environmental Sensing Systems, Australia; darius.culvenor@sensingsystems.com.au*), Newnham, G. (*Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia; glenn.newnham@csiro.au*).

Natural eucalypt forests are extensive ecosystems in Australia and important carbon stores on a national level. Established methods for measuring eucalypt growth dynamics, especially crown dynamics, are manually intensive and have high uncertainties. A recently developed ground-based LiDAR sensor (VEGNET™) produces automated and daily measures of leaf area index (LAI) and vertical foliage profiles. For this study, three sensors were deployed continuously for 2 years in a dry sclerophyll eucalypt forest in combination with a number of well-established growth measurement methods like eddy covariance flux tower, hemispherical images, litter fall, and micro-dendrometers. The authors studied the potential of VEGNET™ alone and in combination with other methods (1) to accurately represent LAI and vertical structure dynamics, (2) to partition carbon allocation between root, stem, and crown biomass pools, and (3) to decrease uncertainties associated with stand growth dynamics. Data indicate that the VEGNET™ sensors agree well with established methods, but greatly improve the accuracy and feasibility of quantifying dynamics of biomass vertical distribution. Net primary production can be partitioned more easily between each pool, and the seasonal dynamics of each can be continuously monitored. Thus, this automated multiple-method approach including the novel VEGNET™ sensors clearly demonstrates the potential to decrease uncertainties associated with forest growth measurements.

Modeling forest biomass baselines in miombo forests of southern Africa: approaches and uncertainties. Halperin, J., LeMay, V., Marshall, P., Coops, N., Verchot, L. (*University of British Columbia, Canada; j.halperin@alumni.ubc.ca; Valerie.LeMay@ubc.ca; peter.marshall@ubc.ca; nicholas.coos@ubc.ca*), Verchot, L. (*Center for International Forestry Research (CIFOR), Indonesia; l.verchot@cgiar.org*).

Obtaining forest biomass baseline estimates and associated uncertainties continues to elude forest monitoring practitioners in tropical forests. These baselines are fundamentally needed as a critical step in moving forward with REDD+ MRV systems. Without this critical information, countries lack the information needed to plan and implement climate change mitigation and adaptation strategies. Further, methods to estimate these baselines must be sensitive to anticipated changes within forests and must be flexible to allow for monitoring at spatial and temporal scales consistent with the drivers of these changes. Combining forest inventory and remotely sensed data to develop forest biomass estimates that can be obtained for multiple scales would contribute to obtaining these necessary baseline estimates. In this study models were developed to estimate biomass using imputation or spatial interpolation, or a combination thereof. Data for this study included high resolution imagery from the RapidEye satellite and a 10 km × 10 km network of ground-measured permanent sample plots established within the Zambian National Forest Inventory framework. This paper discusses the accuracy of each approach and its relevance for monitoring changes. The potential for repeatability of these same methods using lower resolution satellite imagery, such as Landsat, is highlighted.

Simulating effects of forest management on European forest carbon stocks and carbon balance. Härkönen, S., Mäkelä-Carter, A., Berninger, F. (*University of Helsinki, Finland; sanna.harkonen@metla.fi; annikki.makela@helsinki.fi*), Aachen, W. (*Université Libre de Bruxelles, Belgium; wouter.achten@ulb.ac.be*), Chirici, G. (Italian Academy of Forest Sciences*, Italy; gherardo.chirici@unimol.it*), Hasenauer, H. (*University of Natural Resources and Life Sciences (BOKU), Austria; hubert.hasenauer@boku.ac.at*), Marchetti, M. (*Italian Academy of Forest Sciences, Italy; marchettimarco@unimol.it*), Merganic, J., Merganicova, K. (*Czech University of Life Sciences, Czech Republic; merganic@fld.czu.cz; merganicova@fld.czu.cz*), Mohren, G. (*Wageningen University, the Netherlands; frits.mohren@wur.nl*), Moreno, A. (*University of Natural Resources and Life Sciences, Austria; adam.moreno@boku.ac.at*), Mues, V. (*University of Hamburg, Germany; volker.mues@uni-hamburg.de*), Mura, M. (*University of Sassari, Italy; mrmura@uniss.it*), Mura, M. (*University of Molise, Italy; mur.teo@gmail.com*), Neumann, M. (*University of Natural Resources and Life Sciences, Austria; mathias.neumann@boku.ac.at*), Svoboda, M. (*Czech University of Life Sciences, Czech Republic; svobodam@fld.czu.cz*).

This paper introduces the new FORMIT forest growth simulator, which is a climate-sensitive summary model framework developed for estimating forest gross primary productivity, net primary productivity (NPP), and net ecosystem exchange for different regions in Europe. The simulator consists of several sub-models which are either based on earlier modeling studies or new regional models fitted with National Forest Inventory NFI) data from different parts of Europe. The simulator can be run based on basic forest inventory data (dominant species, mean height, mean diameter, mean crown base height, basal area) and daily weather data. The FORMIT simulator includes the most typical management systems (thinnings + clear-cut) practiced currently in different parts of Europe and it is capable of simulating development of either managed or natural even-aged forests. In this paper the simulator will be tested in different ecological regions from Northern, Western, Southern, and Middle-Europe, and will be evaluated against NPP estimates derived from measurements of two NFI rounds between 2000 and 2010. The test areas are in Finland, Czech Republic, Germany, Austria, Belgium, and Italy. The simulator allows users to examine long-term development of carbon stocks and carbon balance in European forests with business-as-usual management. It also allows examination of effects of adjusted management regimes, such as longer rotation lengths or lighter thinnings, to the long-term carbon balance.

An idea of things to come: using satellite observations for assessing site-specific sensitivities of European beech to excessive drought conditions. Hill, J., Stellmes, M., Stoffels, J. (*Trier University, Germany, Germany; hillj@uni-trier.de*), *stellmes@uni-trier.de; Stoffels@uni-trier.de*), Langshausen, J. (*Rhineland-Palatinate State Forest Administration, Germany; Joachim.Langshausen@wald-rlp.de*).

The recently published IPCC report states that temperatures and length, frequency, and intensity of warm spells or heat waves might increase over all of Europe. Reliable information about the sensitivity of important tree species to climate is therefore of utmost importance for maintaining forest productivity. The climate sensitivity and drought tolerance of European beech (one of the economically most important species in Germany) have already been the subject of various empirical studies and modeling approaches. Although revealing potential adaptation abilities and site limitations on a large spatial scale, results do not necessarily support site-specific decision-making. In the federal state of Rhineland-Palatinate (Germany), as in most of Europe, the summer of 2003 was one of the hottest and driest on record; climatologists suggest it provided a realistic idea of future climate scenarios. The authors used calibrated satellite observations collected during the drought progression to examine stands occupied by European beech which were suffering from water shortage. By mapping the decreasing forest canopy water content across

regional environmental gradients, site-specific stress levels for European beech were identified with respect to spatially explicit evapotranspiration and solar radiation estimates. Results indicate substantial differences within the range of sites and might be used to support site-specific forest management decisions.

Using forest land cover disturbance detection as a proxy for monitoring water quality in the Lake Michigan and Lake Superior Basins, USA. Housman, I., Seilheimer, T., Perry, C.H., Nelson, M., Stueve, K. (*U.S. Forest Service, USA; ihousman@fs.fed.us; tseilheimer@aqua.wisc.edu;charleshperry@fs.fed.us; mdnelson@fs.fed.us*), *kstueve@biogeography.us*).

As part of the Great Lakes Restoration Initiative, the capability of remote sensing-based forest land cover disturbance products to monitor water quality was tested. An enhanced version of the Vegetation Change Tracker (VCT) was applied to quantify landscape-level patterns of forest land cover disturbance across the Lake Superior and Lake Michigan basins. The enhanced version of VCT integrated snow-covered winter imagery to enhance product accuracy. Disturbance data were then related to water quality metrics. Results indicate that areas identified as undergoing forest land cover disturbance showed a decrease in water quality. Based on this study, forest land cover disturbance products from VCT can provide an alternative method for monitoring water quality as it relates to forest land cover disturbances.

Comparison of point clouds from 3D airborne image matching and airborne LiDAR in mapping carbon or tropical rain forest in Indonesia. Hussin, Y., Sumarah, A. (*University of Twente, the Netherlands; hussin@itc.nl; a.dwisumarah@student.utwente.nl*).

Various methods for the derivation of forest stand parameters such as biomass and carbon in the fields of pre-processing, digital surface model (DSM) generation, tree extraction, and classification already exist, but few of them are targeted or even tested on the most recent point cloud based on digital aerial imagery. The high cost of LiDAR operation makes it difficult to get recent and up-to-date LiDAR data. An accurate and up-to-date DSM can be generated from photogrammetric image matching. Thus, a DSM from image matching and a digital terrain model (DTM) from LiDAR can be used for mapping carbon in forest cover. LiDAR can map only in 3D, but photogrammetry can produce 2D and 3D maps. LiDAR is capable of estimating tree height with reasonable accuracy but not tree species and tree density. Aerial 3D photogrammetry can produce more point density than LiDAR at the same height and flight speed, which is more useful for assessing biomass and mapping carbon. The objective of this research was to compare the use of LiDAR airborne data and 3D photogrammetric image matching to estimate and map carbon in the tropical rain forest in Indonesia.

Modeling woody biomass utilization for energy feedstock in the northwest United States. Jacobson, R., Keefe, R. (*University of Idaho, USA; jaco0707@vandals.uidaho.edu; robk@uidaho.edu*).

Woody biomass is a significant potential source of biofuel feedstock. Woody biomass is commonly burned in the inland northwest United States, as opposed to being removed for energy generation, primarily due to a lack of viable markets to utilize the biomass. In order to better understand the potential impacts of woody biofuels development on communities in the northern Rocky Mountains, the authors are using simulation modeling linked with GIS data to evaluate potential local, regional, and international market scenarios representing different biomass development options for the region. Analysis of the production, transportation, and energy generation of woody biomass in the region is separated into three scenarios: a localized scenario using a mobile liquid conversion reactor, a regional scenario in which a large liquid fuel conversion facility (>700,000 bone dry tons/yr) for domestic production is considered, and a third scenario in which a centralized pellet mill exporting to foreign markets is considered. Detailed cost analysis of each scenario will provide inputs to broader economic models used to analyze the economic impacts of each scenario in Washington, Oregon, northern Idaho, and western Montana.

Spatio-temporal assessment of forest cover changes in Mongolia using remotely sensed data. Jamsran, T. (*Institute of GeoEcology, Mongolia; tsogtbaatarj@magicnet.mn*), Sodov, K. (*Environment Information Centre of Mongolia, Mongolia; mtt@magicnet.mn*), Nyamtseren, M. Sumya, A. (*Institute of GeoEcology, Mongolia; maaggi@yahoo.com; khatuusamar@yahoo.com*).

The forests of Mongolia are mainly located in the north-central parts of the country, forming a transition zone between the Great Siberian boreal forest and the Central Asian steppe desert. The geography and ecology of forest ecosystems differ from ecoregions due to bioclimatic conditions in the country, which vary with latitude and longitude. The pressure on Mongolia's forests is high because of the dry climate, high frequency of forest fire, and high ecological risks from forest insect outbreaks. Rapid economic growth in the country over the last two decades has put additional demands on forests for construction and infrastructure development. This study tests the hypothesis of a spatial relationship between land surface temperature (LST) and different vegetation indices (normalized difference vegetation index (NDVI), enhanced vegetation index (EVI), and soil adjusted vegetation index (SAVI)) derived by remotely sensed data to define forest cover extent. To survey temporal changes in forest ecosystems the change detection analysis was done for 2000, 2005, and 2013. Results show that the LST and NDVI are highly correlated within the selected Landsat scene and gave a similar spatial pattern. The spatial homogeneity of NDVI suggested as an indicator to map tree cover and the LST temporal characteristics may indicate a certain level of damage to the forest ecosystem.

Carbon storage, floristic composition, and species diversity in charcoal and agriculture fallows and management implications in miombo woodlands of Zambia. Kalaba, F. (*Copperbelt University, Zambia; kanungwe@gmail.com*).

This paper provides an integrated understanding of aboveground (AG) carbon storage and floristic composition in charcoal and agriculture fallows in miombo woodland systems of Zambia. Tree diameters were measured and species composition was recorded on twenty-four 0.25-ha plots in undisturbed woodlands, and fifty-eight plots re-growing after agriculture (5–58 yr) and charcoal production (5–44 yr). Undisturbed miombo stored 39.6 Mg AG C/ha. After clearing, C stocks accumulated at annual rates of 0.98 and 1.42 Mg C/ha in agriculture and charcoal fallows, respectively. No significant differences were observed in C stocks between woodlands and fallows ≥20 years old, implying that in terms of AG C storage, woodlands sufficiently recover after 20 years. Importance values of tree species show low presence of less fire-resistant tree species in the initial regrowth of

post-agriculture fallows. The study observed low species similarities between mature woodlands and fallows, suggesting that though C storage in miombo systems recovers relatively fast, species composition takes longer to recover. Agriculture and charcoal fallows hold enormous management potential for restoring carbon and biodiversity in degraded forest ecosystems and therefore should be considered under the REDD+ mechanism.

Monitoring and evaluation of impacts of FSC forest management certification. Karmann, M. (*Forest Stewardship Council – FSC International, Germany; m.karmann@fsc.org*).

Within in the Forest Stewardship Council (FSC) system and in the public domain a large amount of information is generated about the outcomes and impacts of certification requirements at the level of each certified forest management operation. To evaluate more systematically the outcomes and impacts that FSC certification triggers in terms of social, environmental, and economic aspects of forest management, the organization set up a monitoring and evaluation (M&E) program. This M&E framework could allow some level of generalization about the complex effects of forest management interventions, the different commodities and services forest management provides in different parts of the world, and FSC's stakeholder engagement. After consultations with stakeholders, a theory of change was developed for the FSC system and intended impacts were identified. Related quantitative and qualitative impact indicators will be monitored regularly at the forest management level. Some indicators will be monitored on case-specific levels only. In addition, the modular approach of FSC's new program allows baseline data to be identified before certification interventions so that forest management interventions can be more clearly attributed to certification requirements. This paper presents the FSC's M&E framework, including research partners, preliminary results, and invitations to further cooperative research.

Comparative assessment of riparian forests based on remote sensing in a Hungarian-Slovakian cross-border area. Király, G., Brolly, G. (*University of West Hungary, kiraly.geza@emk.nyme.hu; gbrolly@emk.nyme.hu*), Sačkov, I., Bucha, T. (*National Forest Center Zvolen, Slovakia; sackov@nlcsk.org; bucha@nlcsk.org*).

High density airborne laser scanning (ALS) along with aerial photography has been carried out over the "Szigetköz" Hungarian-Slovakian cross-border area, as part of a cross-border cooperative project called INMEIN. The area, which is the floodplain of the Danube River, has a very high percentage of cover (75%) in forest, which is endangered by lowering the water level by the Gabčíkovo hydroelectric power station. The dominant forests are poplar plantations, interspersed with patches of natural softwood and hardwood forests along the streams and oxbows. The plantations and close-to-natural forests were compared using remotely sensed data. The basis for these assessments was raw point-cloud data, but additional derived data sets, such as digital surface models (DSM) and canopy height model (CHM) were also included. This objective of this research was to develop methods for deriving dendrometric characteristics of forest stands and single trees. The very high resolution imagery data were used as complementary reference data. Some Hungarian and Slovakian test areas were selected and compared in this investigation. Results of this work will be used to establish a remote sensing- based and harmonised procedure for forest inventory and monitoring in this ecologically very sensitive area.

Estimating aboveground tree biomass in three different miombo woodlands and associated land use systems in Malawi. Kuyah, S., Sileshi, G, Njoloma, J., Mng'omba, S., Neufeldt, H. (*World Agroforestry Centre (ICRAF), Kenya; s.kuyah@cgiar.org; S.Weldesemayat@cgiar.org; j.njoloma@cgiar.org; s.Mng'omba@cgiar.org; H.Neufeldt@cgiar.org*).

Trees outside forests support smallholder farmers' livelihoods and play a critical role in the global carbon cycle. However, their relative contribution to climate change mitigation through carbon storage is not obvious because of limited information regarding their extent, and inadequate methods for quantification. This study evaluated the distribution of aboveground tree biomass in three 100-km^2 sentinel sites, Kasungu, Salima, and Neno in Malawi. More than 100 species and a total of 2 481 trees were inventoried at 67 sample plots covering 37 cultivated fields and 30 woodland plots. The three most dominant species in terms of biomass were *Faidherbia albida* (47.8%), *Piliostigma thonningii* (10.5%), and *Mangifera indica* (8.9%). High biomass trees (i.e., those with DBH >40 cm), formed less than 1% of the total population inventoried in Salima, but held >60% of the biomass. Smaller trees (DBH <10 cm) dominated all the sites, representing 92.9% of all the trees measured. Biomass was disproportionally distributed, with high biomass estimated in Salima and low biomass estimated in Kasungu and Neno. The biomass estimates established in this study provide a useful benchmark against which future estimates can be compared, and sets a baseline for calculating changes in carbon stocks over time.

Carbon stores in Ukrainian forests: current stock and midterm forecast. Lakyda, P., Vasylyshyn, R., Bilous, A., Zibtsev, S. (*National University of Life and Environmental Sciences of Ukraine, Ukraine; lakyda@nubip.edu.ua; rvasylys@ukr.net; abels@ukr.net; sergiy.zibtsev@nubip.edu.ua*).

Forests cover 9.6 million ha or 15.9% of Ukraine with a total growing stock of about 2.1 billion m^3 and an average of 220 m^3/ha, according to 2011 government data. Current total stock of deposited carbon in Ukrainian forests is estimated as 758 Tg or 9.3 metric tons C/ha. Almost 48% of carbon is stored in hardwoods, and the balance is in conifers. More than 26 Tg of carbon are deposited in dead wood (92.6 million m^3). Total net primary productivity (NPP) in Ukrainian forests is 49.0 Tg C/yr or 512 g C/m^2/yr on average. It is almost 67% higher than the average NPP for Russian forests (317 g C/m^2/yr) (Shvidenko *et al*., 2012). Based on an analysis of data from the past two decades and recent trends in social-economic development (current and expected funding of forestry, current levels of reforestation and afforestation, conservative forecast of harvesting), carbon stores in Ukrainian forests are projected to reach 860 Tg by 2030. This estimate represents a 12% increase by midterm.

An object-based analysis of high resolution imagery to map canopy cover across semi-Mediterranean stands in western Iran. Latifi, H. (*University of Wuerzburg, Germany; hooman.latifi@uni-wuerzburg.de*), Naghavi, H. (*University of Lorestan, Iran; hm.naghavi@gmail.com*), Fallah, A. (*Sari Agricultural Sciences and Natural Resources University, Iran; a.fallah@sanru.ac.ir*), Shataee, S. (*Gorgan University of Agricultural Sciences and Natural Resources, Iran; shataee@yahoo.com*), Conrad, C. (*University of Wuerzburg, Germany; christopher.conrad@uni-wuerzburg.de*), Soosani, J. (*University of Lorestan, Iran; javad.soosani@yahoo.com*), Ramezani, H. (*Swedish University of Agricultural Sciences, Sweden; habib.ramezani@slu.se*).

The Zagros forests cover approximately 5 million ha of mountainous areas in semi-Mediterranean western Iran, forming a crucial source of ecosystem services such as genetic diversity, erosion control, and non-timber forest products. Yet the sites are severely threatened by overgrazing, cultivation in understory, wildfire, and erosion. Thus, a sufficient inventory of existing tree cover is highly essential for protection purposes. The authors pursued a hybrid method to combine ground samples and high resolution Quickbird imagery for mapping canopy cover in an area encompassing 1 200 ha of unmanaged *Quercus brantii* stands. The focus was on defining an optimum sampling design by testing various approaches within a 100-ha 100%-inventoried subarea. The entire site was then sampled by 0.1-ha circular plots. The plot data were associated with the original and synthetically derived spectral metrics from Quickbird imagery using nonparametric classification of image segments. Results indicated that the applied metrics have a medium to high potential for producing canopy cover maps at the plot as well as segment level. The authors concluded that their methodology could help with inventories of highly fragmented, unmanaged stands in similar areas. Care should be taken when deriving soil-adjusted vegetation indices, where a strong background soil reflectance generally exists.

Change analysis of Myanmar dryland land cover and vegetation temperature condition index. Lee, E., Lee, W., Choi, S., Yu, H., (*Korea University, Republic of Korea; leeej1212@korea.ac.kr; leewk@korea.ac.kr; saymi0630@nate.com; willpower0129@gmail.com*), Kang, H. (*Dongguk University, Republic of Korea; ccdasa@naver.com*).

Myanmar is one of the developing countries affected by land degradation mainly resulting from inappropriate land use practices. Dryland of Myanmar is the most problematic region because of low productivity of agricultural crops, forest degradation, and adverse soil and climate conditions. The main causes of land degradation are demographic pressure on agricultural land, over-grazing, shifting cultivation, and illegal logging. To begin to address land degradation in the dryland of Myanmar, this study investigated land cover change as a first step. Then the vegetation temperature condition index (VTCI), which was derived from the normalized difference vegetation index (NDVI) and land surface temperature (LST), was used to observe changes in the distribution of vegetation. The VTCI can be used to monitor drought occurrences at a regional level over a given period, and to study the spatial distribution of drought within the region. The VTCI and land cover change map were used to explore relationships between human impacts and climatic variables. This study was carried out with the support of "Forest Science Technologies Development Project (Project Number: S211213L030320)" provided by the Korea Forest Service.

Zoning productivity and growth constraints for eucalyptus forest plantations in southeastern of Brazil
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In a competitive market for land with other crops, zoning productivity can help forest managers to make decisions about land choice and occupation, based on technical information of forest productivity. The objectives of this study were to map the actual productivity of eucalyptus forest plantations in southeastern Brazil and to determine the constraints of forest growth. The estimation of productivity was made by integrating the 3PG model modified by soil water content with GIS tools. For this purpose, maps of monthly rainfall, maximum temperature, and minimum temperature, and soil maps were used. To evaluate model performance, the mean annual increment at 7 years (MAI7) estimated by 3PG was compared with projections based on inventory measurements (1 884 plots dispersed in 58 000 ha). Average eucalyptus productivity from 3PG estimation and inventory projection was similar, 42 m^3/ha/yr. However, the comparison of the MAI7 between measured and predicted stratified by soil type and farm, presented a high data dispersion, probably because of the average climate data used as model input, soil type detailing, genetic material adaptation, and silviculture management, or the interaction of those factors. Nonetheless, it was possible to zone eucalyptus productivity, and the main growth constraints were vapor pressure deficit and soil water content.

Forest cover dynamics of the Dxing'anling Forest Zone over the last four decades. Li, S. (*Institute of Forest Resources Information Techniques, CAF, China; lism@caf.ac.cn*).

Spatial information inherent within imageries presents opportunities to generate unique and ecologically important forest cover maps. Over the last 40 years, the focus of forest management policy in China has changed from wood production, to wood harvesting, protection and utilization, and most recently to ecological services and functions. This study investigated forest cover dynamics in the Dxinganling Forest Zone over the last three decades using time-series of Landsat TM/ETM+ imagery. Time-series of forest cover maps were produced by supervised classification of Landsat images acquired in the 1980s, 1990s, 2000s, and 2010s. The dynamics of forest cover were analyzed by using time-series of forest cover map and supplementary data including digital elevation models, forest inventory data, and social-economic and policy factors to identify the reasons of forest cover change.

Using MODIS data to estimate the leaf area index of different forest types in Taiwan. Lin, T., Chen, J. (*National Pingtung University of Science and Technology, China-Taipei; ybf90905@hotmail.com; zzz.john@msa.hinet.net*), Hsu, L. (*Chinese Culture University, China-Taipei; lita@faculty.pccu.edu.tw*), Chen, C. (*National Pingtung University of Science and Technology Pingtung, China-Taipei; cct@gisfore.npust.edu.tw*).

Leaf Area Index (LAI) is one of the most important factors in forest ecosystems for evaluating energy fluxes. Traditional direct measurements of LAI are usually costly and time-consuming, and are unable to cover large areas. In recent years, there has been a tendency to estimate large-scale LAI based on the multiple spectral characteristics of satellite images. The NASA Website continually provides free MODIS time- series data for monitoring forest ecosystems. In this study, the relationships between field- measured LAI data and the vegetation indices derived from FS2 satellite images were examined. The result showed that the normalized difference vegetation index (NDVI) was a good indicator of LAI. The regression equation, LAI = 8.8997(NDVI)1.4937 (R^2=0.74), was used to estimate the spatial distribution of LAI, and was subsequently applied to the MODIS imagery to analyze spatial patterns and temporal trends. The results showed that the LAI of all forest types decreased as the temperature rose between 0.2 and 0.6 °C from 2001 to 2009. In terms of precipitation, the drought in 2002 significantly decreased the LAI of forests except for alpine forests. The results of time-series analysis showed a long-term trend of decreasing LAI for all forest types.

The U.S. Government's SilvaCarbon Program: technology transfer for MRV development. Lister, A. (*U.S. Forest Service, USA; alister@fs.fed.us*).

SilvaCarbon is a multi-agency program of the U.S. government that aims to provide technical support to developing countries seeking to participate in the United Nations' REDD+ program. SilvaCarbon works in the Andean Amazon region (Colombia, Ecuador, and Peru), South East Asia region (Indonesia, Philippines, Thailand, Vietnam, Cambodia, Lao PDR, and Nepal), and Africa region (Cameroon, Gabon, Democratic Republic of Congo, and Central Africa Republic). The goal of the program is to provide assistance in the implementation of monitoring, reporting, and verification systems (MRV) for REDD+ by developing and delivering good practice guides, manuals, training, and tools; facilitating learning exchanges, regional forums, and networks to enhance sharing among countries; providing technical advice and assistance to governments, including Global Forest Observation Initiatives (GFOI) countries; and partnering with other donors and with international organizations to multiply impact and reach. This presentation provides an opportunity to show some of the outcomes from the capacity building in these regions, and how a coordinated program can multiply the impact of international cooperation.

The variations analysis of forest canopy closure estimated from airborne LiDAR data. Liu, Q., Li, S., Li, Z., Chen, E., Pang, Y. (*Chinese Academy of Forestry, China; liuqw@ifrit.ac.cn; lism@caf.ac.cn*; *lizy@caf.acn.cn; chenerx@caf.ac.cn; pangy@caf.ac.cn*).

The 3D structure of forest canopies can be characterized using airborne LiDAR data, and forest biophysical parameters can be obtained by allometric equations. Forest canopy closure is one of the important features of forest stand structure, and can be used as an indicator of the redistribution of environmental parameters such as light and water in forest stands. It could be expressed as the ratio of different return points. The estimation accuracy of forest canopy closure was affected considerably by flight platform parameters, LiDAR system configurations, data processing algorithms, and other factors. The test site is located in the Gansu Qilian Mountains National Nature Reserve of China. Airborne LiDAR data were acquired in June 2008. The study demonstrated the variability of forest canopy closure estimates derived from laser cloud point data under different conditions. Results can be used to facilitate planning of flight campaigns that reflect the accuracy requirements of different tasks.

Evaluation of permanent sites for monitoring and modeling biomass and CO_2 in Mexico's mixed forests. Lopez-Ochoa, L., Treviño Garza, E., Aguirre Calderón, O., Jimenez, J., Alanis, E. (*Universidad Autónoma de Nuevo León, Mexico; lopezochoa.luis@gmail.com; eduardo.trevinogr@uanl.edu.mx; oscar.aguirrecl@uanl.edu.mx*, *jjimenez20@gmail.com; alanis_eduardo@yahoo.com.mx*).

There is worldwide concern about climate change, which has mainly been attributed to increased concentrations of greenhouse gases. As a response to this problem, mechanisms have been created to reduce emissions from deforestation and forest degradation, attributing a monetary value based on their ability to store carbon. The aim of this study was to calculate the aerial biomass and CO_2 of individual trees in 11 research plots using allometric models. With these estimates it is possible to calculate stored carbon, which indicates the attenuator effect (sink) of a species as it removes excess greenhouse gases. The research plots are located in the Sierra Madre Oriental south of the state of Nuevo León, Mexico. Analysis of reported data showed that the main species found on these plots were *Pinus pseudostrobus*, *P. teocote*, *P. cembroides*, *Abies* spp., *Quercus laeta*, *Q. polymorpha*, and *Arbutus xalapensis*. Being reported that only in 2.75 corresponding surface of the 11 plots, there is a total of 758 Mg of aerial biomass equivalent to 1 437 Mg of CO_2 stored. The models adequately estimate biomass and CO_2 and have good statistical adjustments.

Geospatial biomass estimation in the Sierra Madre Occidental in Durango (Mexico). Lopez Serrano, P., López-Sánchez, C., Corral Rivas, J. (*Universidad Juárez del Estado de Durango, Mexico; inglopez_13@hotmail.com; calopez@ujed.mx; jcorral@ujed.mx*, Vargas-Larreta, B. (*Instituto Tecnológico de El Salto, Mexico; bvargas@itelsalto.edu.mx*).

The Sierra Madre Occidental is the largest mountain range in Mexico. It has great environmental complexity and is of major ecological, biological, and economic importance because it provides habitat to many tree species, mainly *Pinus*, *Quercus*, and *Arbutus* spp. Because of the extent and economic value of its forest resources, the Durango is considered the most important state in Mexico. Combining geospatial tools and non-parametric multivariate statistical analysis such as classification and regression tree analysis (CART) has proved to be a useful technique for estimating forest biomass in tree plantations. The goal of this study was to estimate the amount of biomass in two mixed, uneven-aged forest regions in Durango using Landsat TM5 spectral data. Multispectral images from April 2011 were used, along with data from permanent sample plots collected during the same year. Sites are 50 m × 50 m in size and were placed using systematic sampling throughout the study areas. The digital levels were transformed into reflectance values (%) and the normalized difference vegetation index (NDVI). Biomass estimation was obtained using the CART approach. Pixels reflected 81.25 Mg/ha of forest biomass on average (R^2 = 0.63, RMSE = 36.5). Study findings indicate that combining remote sensing imagery and non-parametric multivariate statistical techniques allows the estimation of forest biomass with a good overall accuracy in the mixed and unmanaged forest stands studied in Durango.

The effect of changing forests on seasonal patterns of the albedo in boreal forests. Lukeš, P., Rautiainen, M., Stenberg, T., Mõttus, M. (*University of Helsinki, Finland; petr.lukes@helsinki.fi; miina.rautiainen@helsinki.fi; pauline.stenberg@helsinki.fi; matti.mottus@helsinki.fi*), Manninen, T. (*Finnish Meteorological Institute, Finland; Terhikki.Manninen@fmi.fi*).

Forests play an important role in global change. The area and density of the world's forests influence global climate via feedback mechanisms such as the land surface albedo. Globally, the area of forests is decreasing, but in the boreal forest zone both area and biomass stored in the forests continue to increase. However, there is an acknowledged need for more reliable quantitative assessments of how changes in forest biomass and structure affect the land surface albedo. This need applies in particular to boreal forests, which are characterized by a very heterogeneous structure, combined with snow-covered ground in winter. A physically based albedo model was parameterized for the boreal region using forest inventory data and measured spectral data on forest elements, understory, and snow. The model was validated using global satellite and land cover data. Model simulations

were made to derive generic relationships between forest structure and biomass and shortwave albedo. The results were applied to predict the effect of changing forests on the albedo throughout the season.

RapidEye object-based image classification and landscape ecology analysis to support the geospatial component of the Brazilian National Forest Inventory. Luz, N. (*Fundação de Amparo à Pesquisa do Estado de Goiás (FAPEG), Brazil; naissa@gmail.com*), Oliveira, Y.M., Rosot, M., Garrastazu, M., Mattos, P., Franciscon, L. (*EMBRAPA, Brazil; yeda.oliveira@embrapa.br; augusta_rosot@hotmail.com; marilice.garrastazu@embrapa.br; patricia.mattos@embrapa.br; luziane.franciscon@embrapa.br*), Freitas, J., Piotto, D., Gomide, G., Souza, G. (*Brazilian Forest Service, Brazil; joberto.freitas@florestal.gov.br; daniel.piotto@florestal.gov.br; guilherme.gomide@florestal.gov.br; gilson.souza@florestal.gov.br*).

In response to the growing demand for reliable information on forest and tree resources as well as for land use/land cover (LULC) maps at larger scales, the Brazilian National Forest Inventory (NFI-BR) is now being conducted. Besides the traditional approaches related to forest assessment, the NFI-BR includes a geospatial component to provide such information at landscape scale. Using a sampling grid of 20 km × 20 km, field registry sample units were established, and 100-km^2 landscape sample units were located on a 40 km × 40 km grid. LULC maps at 1:50000 scale are being prepared for each LSU using RapidEye imagery. The mapping approach uses object-based image classification and newly developed vegetation indices. Attributes from image objects such as spectral characteristics, texture, and context are also involved in process tree classification. A special feature of the LULC map legend is the inclusion of trees outside forests (TOFs), which are isolated trees or small groups of trees not classified as forests. LULC maps are the basis for analyzing landscape-scale forest fragmentation analysis as well as for evaluating compliance of permanent preservation areas under recently approved environmental legislation.

Remote sensing, GIS, and successive inventory for forest resource assessment in the Blue Nile region, Sudan. Mahmoud El-Abbas, M. (*Dresden University of Technology, Germany; mmelabbas@hotmail.com*), A. Elsiddig, E. (*University of Khartoum, Sudan; elnour-elsiddig@yahoo.com*).

Well-designed information systems and management plans are needed as the forest sector in Sudan faces many challenges. One of these challenges is land use/land cover (LULC) changes, particularly deforestation and land degradation. To cope with this issue, the efficiency of successive forest inventory was tested in vast areas of the Blue Nile region. In order to estimate the change, a field mission was conducted in 2005 to revisit the same plots determined within the framework of an AFRICOVER project in 1996. Earth observation data were used to assess the estimates from field inventories. The study showed a high correlation for LULC data obtained by the two methods. Meanwhile, data collected from successive inventory provide detailed information about the vegetation cover. In the area under investigation, results showed the forest land was drastically decreased and degraded. The agrarian structure in conversion of forest into agricultural fields and grassland was considered to be the main cause of deforestation. To conclude, remote sensing and GIS are efficient tools and have been effectively used to estimate large-scale LULC and its dynamics in a timely and cost-effective manner.

Developing modular methods for predicting forest growth responses to environmental change. Mäkelä-Carter, A., Nikinmaa, E., Härkönen, S. Kalliokoski, T., Kolari, P. (*University of Helsinki, Finland; annikki.makela@helsinki.fi; eero.nikinmaa@helsinki.fi; sanna.harkonen@helsinki.fi; tuomo.kalliokoski@helsinki.fi; pais.kolari@helsinki.fi*), Linkosalo, T., Mäkipää, R., Peltoniemi, M. (*Finnish Forest Research Institute (METLA), Finland; tapio.linkosalo@metla.fi; raisa.makipaa@metla.fi; mikko.peltoniemi@metla.fi*), Valsta, L. (*University of Helsinki, Finland; lauri.valsta@helsinki.fi*).

Prediction of forest growth under climate change involves quantification of a multitude of impacts at different spatial and temporal scales. Few ecosystem models incorporate all the essential impacts simultaneously, and single models easily become too complex to parameterise for larger areas or longer time spans. Much information about forest ecosystem functioning is quantified in different models. The Helsinki Integrated Forest Impact Model System (HIFI-MS) approach is to combine models in a modular system for estimating climate change impacts at a regional scale. The method is applied to adaptation of forest management under climate change in southern Finland. Process models were used to predict daily net primary productivity and C and N release from the soil. The results were expressed as parameters of a stand growth model and mapped over the region. A growth model with optimal C:N allocation was applied to derive the climate-sensitive parameters to carbon allocation. These were translated into changes in volume growth and used as input to an empirical growth model to estimate regional forest growth changes. The authors' models predict that despite increasing growth potential with climate change, the initial age distribution of stands will largely determine the total growth in the region for 40–50 years. After this period, climate scenarios and management options start to influence the outcome.

Intra-annual xylem formation of Norway spruce and Scots pine across a latitudinal gradient in Finland. Mäkinen, H., Jyske, T., Kalliokoski, T., Nöjd, P. (*Finnish Forest Research Institute (METLA), Finland; harri.makinen@metla.fi; tuula.jyske@metla.fi; tuomo.kalliokoski@metla.fi; pekka.nojd@metla.fi*).

The expected changes of climate call for better insight into the growth responses of trees to varying environmental conditions over large geographical regions. The authors analysed the intra-annual xylem formation of Norway spruce (*Picea abies* (L.) Karst.) and Scots pine (*Pinus sylvestris* L.) across a latitudinal gradient in Finland (60–68°N). The number of tracheids and the onset, highest rate, and cessation of xylem formation were determined in nine stands during growing seasons of 2001–2009. Tracheid formation initiated earlier and ceased later for Scots pine than for Norway spruce. In northern Finland, xylem formation started later and ceased earlier than in the south. The temperature sum (TS) at growth cessation was lower in the north. In the northernmost stand, the length of the growing season was less than 2 months and the onset of xylem formation required lower TS than elsewhere. The highest tracheid formation rate occurred slightly after the summer solstice, but differences between sites and variation by year were high. The results imply that year-to-year weather variation has a marked impact on the timing of xylem formation. However, the results support the hypothesis that the provenances have adapted genetically and adjust their wood formation to local conditions.

Industrial forest mapping with satellite data. Marini, L., Boschetti, L., Smith, A., Keef, R. (*University of Idaho, United States; mari3635@vandals.uidaho.edu; luigi@uidaho.edu; alistair@uidaho.edu; robk@uidaho.edu*), Hudak, A. (*U.S. Forest Service, USA; ahudak@fs.fed.us*).

Remote sensing has been widely used for mapping and characterizing changes in forest cover. A change in land cover highly amenable to remote sensing is deforestation. The available remote sensing forest change products are suitable for estimating total change in forest cover but are not discriminating between deforestation and industrial forest management. Current estimates of carbon-equivalent emissions report the contribution of deforestation as 12% of total anthropogenic carbon emissions (van der Werf *et al*., 2009), but accurate monitoring of forest carbon balance should discriminate between land use change related to forest natural disturbances, and forest management. The total change in forest cover (Gross Forest Cover Loss, GFLC) needs to be characterized based on the cause (natural or human) and on the outcome of the change (regeneration to forest, or transition to non-forest). Industrial forestry today is highly optimized: economic profitability forces the adoption of standard practices that result in very clear spatial patterns evident to human interpreters, but hardly detectable with traditional satellite mapping approaches. To overcome these challenges, the authors propose a methodology for distinguishing between deforestation and forest management practices that combines the use of multitemporal Landsat data time-series, and object-oriented analysis of shapes, textures, and spatial relationships of the areas of deforestation/afforestation.

Modeling the uncertainty of climate change impacts on *Eucalyptus fastigata* productivity in New Zealand. Meason, D. (*Scion, New Zealand; dean.meason@scionresearch.com*), Palma, J. (*University of Lisbon, Portugal; joaopalma@isa.ulisboa.pt*), Harrison, D. (*Scion, New Zealand; duncan.harrison@scionresearch.com*).

Eucalyptus fastigata is a fast-growing eucalypt that is suitable to a wide range of New Zealand environments. It has good wood properties and is well suited for carbon sequestration. Process-based modeling would suggest that under climate change, its growth will increase to rival *Pinus radiata,* the dominant forest species. However, modeling future productivity is fraught with uncertainties: variability of a future climate, including extreme weather events, and its impact on productivity. The uncertainties of site environmental data further complicate such an analysis. Detailed information on soil type and depth are very sparse in forest areas. This information is difficult and expensive to obtain, but could have a major impact on modeling. To provide better certainty of the potential productivity of *E. fastigata*, a series of climate change scenarios (global temperature rise of 2 °C) was made with the process-based model 3PG. To address uncertainties with soil characteristics, a series of available soil water and depth scenarios was investigated. This study provides spatial information about climate change impacts to decision-makers. Results include mean potential productivity under climate change scenarios and a quantification of uncertainty. Regions where *E. fastigata* would be most vulnerable to climate change are identified.

Land use and land cover change estimation – a sample strategy for monitoring. Megown, K., Brewer, K., (*U.S. Forest Service, USA; kamegown@fs.fed.us*), Brewer, K. (*U.S. Forest Service (retired), USA; ckbrewer01@gmail.com*), Webb, J., Lister, A., Finco, M. (*U.S. Forest Service, USA; jwebb@fs.fed.us; alister@fs.fed.us; mfinco@fs.fed.us*).

This submission offers a means to independently monitor information regarding land use and land cover, over space and time. This strategy provides a way to evaluate the complex interactions between human and biophysical systems, to project future conditions absent policy changes, and to design mitigation and adaptive management strategies. This work is supported by photointerpretation methods developed in conjunction with the U.S. Forest Service, Forest Inventory and Analysis program and remote sensing data. Concepts of interpretation, methods of interpretation, an estimation strategy, and finally land use and land cover changes will be shown for the states of Colorado, Georgia, and Washington.

Landsat-MODIS data fusion for automatic mapping of fire disturbances in a forest environment. Melchiorre, A., Boschetti, L. (*University of Idaho, USA; melc2617@vandals.uidaho.edu; luigi@uidaho.edu*), Roy, D. (*South Dakota University, USA; david.roy@sdstate.edu*), Baraldi, A., Humber, M. (*University of Maryland, USA; andrea6311umd@gmail.com; mhumber@umd.edu*).

Satellite data have been used to monitor forest fire for more than three decades using automatic algorithms that detect the location of fire at the time of satellite pass and the spatial extent of the areas affected by fire. MODIS sensors have dedicated fire monitoring capabilities, and their data are used to systematically generate daily global 1-km active fire and monthly 500-m burned area products. Neither MODIS product can detect the incidence or extent of fire reliably at the scale of tens of meters. The free Landsat data policy now provides the opportunity for continental- to global-scale Landsat 30-m resolution processing. The authors present a multi-temporal methodology to fuse the MODIS active fire and burned area products with Landsat data to map burned forest areas at 30 m on a temporally rolling basis. To demonstrate the methodology, 30-m burned area maps of the western United States were generated using the free Web Enabled Landsat (WELD) mosaics (http://landsat.usgs.gov/WELD.php). Validation was conducted by systematic comparison with fire perimeter vectors provided by the U.S. Geological Survey Monitoring Trends in Burn Severity project. Prospects for future development and continental application are discussed. The methodology demonstrates the potential use of the Landsat archive to generate a long-term 30-m fire data record.

Can detailed physiological measurements be efficiently used in forest modeling? Merganicova, K., Merganic, J., Strelcova, K., Fabrika, M. (*Technical University Zvolen, Slovakia; merganicova@tuzvo.sk; j.merganic@forim.sk; strelcova@tuzvo.sk); fabrika@tuzvo.sk*), Sitkova, Z. (*National Forest Centre, Slovakia; sitkova@nlcsk.org*), Lestianska, A., Nalevankova, P., Kurjak, D. (*Technical University Zvolen; lestianska@tuzvo.sk; nalevankova@tuzvo.sk;kurjak@tuzvo.sk*).

The performance of forest growth models is usually examined by comparing model output with data collected in the field. Such tests require comparability of the modeled and the measured parameters to ensure that results of the validation studies are plausible. The presented study addressed the quality of continual measurements of tree circumference, sap flow, and soil water content in European beech forests in central Slovakia, and the possibility of using them in process-based forest ecosystem modeling. Diurnal measurements of stem circumferences include the changes caused by two different processes: changes due to tree growth and changes caused by fluctuations in water balance of tree tissues. Hence, if such data are to be used for modeling

diurnal tree increment, the changes due to stem contraction or expansion need to be eliminated. On the other hand, allocation algorithms used to distribute the assimilated carbon to individual tree components are crucial parts of the models that can affect the comparison of modeled and measured values representing diameter increment at a certain tree height. This study examined the possibilities of eliminating these sources of uncertainty and the potential for using continual experimental measurements for model validation.

Considerations for using a plot-based approach to model forest biomass and canopy structure at the landscape level using LiDAR technology. Mitchell, B., Schrader-Patton, C. (*U.S. Forest Service, USA; brentmitchell@fs.fed.us; cschrader@fs.fed.us*).

The U.S. Forest Service views the inventory and monitoring of forest biomass and canopy structure as a critical part of managing its natural resources. Within the last decade LiDAR technology has been used by the Forest Service to create landscape GIS layers for inventory parameters such as biomass, basal area, and timber volume. For the models to be logical and conform to trends known to occur on the landscape, strong agreement between field plot measurements and corresponding LiDAR metrics must be observed. This relatively new approach to modeling forest structure across the landscape brings with it new challenges and considerations when compared to traditional forestry practices. This presentation highlights the appropriate field data collection protocols and data integration techniques when the goal is combining field and LiDAR data to create forest biomass and canopy structure GIS models.

A proposed coastal pine reforestation model on the Great East Japan Earthquake. Mizutani, K. (*Forestry and Forest Products Research Institute, Japan; mizutani@ffpri.affrc.go.jp*), Kodani, J. (*Ishikawa Agricultural and Forestry Research Center, Japan; kodani@pref.ishikawa.lg.jp*).

Coastal pine forests suffered severe damage from the Great East Japan Earthquake in 2011, demonstrating the need to regenerate strong forests capable of withstanding great tsunami. An experiment involving pine reforestation with direct seeding of devastated coastal land has been conducted since 2007. Suitable stem density was achieved by plowing, burying to a depth of about 4 cm, and mulching using dried pine branches. The method appears feasible as growth is likely to be satisfactory even without weeding. The pine forest withstood the Great East Japan Earthquake relatively well. Coastal banks housing pine forests growing naturally through crevices did not collapse. Such coastal banks, where banks and pine forest come together, are strong and have become a model for regeneration. It is recommended that the regeneration of coastal pine forests shift from traditional planting to natural or direct seeding. Accordingly, the authors propose a regeneration model which covers the bank from the sea side to the land side. Regenerating the coastal forest via this method will protect the bank and allow it to withstand disasters like the great tsunami.

Urban forest identification with high resolution remote sensing. Monteiro, M.M.G., Batista, D.B., Martini, A. (*Federal University of Paraná, Brazil; mayssamonteiro@gmail.com; dbiondi@ufpr.br; martini.angeline@gmail.com*).

Urban forests are increasingly recognized as an important component in improving a city's environmental condition. The high spatial resolution in remote sensing can provide a large amount of spatial data in a short time, from which urban forests can be identified, quantified, and analyzed for spatial distribution within a city. The aim of this research was to verify the applicability of high spatial resolution remote sensing techniques to identify urban forests. The "Jardim Botanico" district, Curitiba/Paraná, Brazil, was selected as the study area because of the presence of different types of green areas. A GeoEye1 image sensor was used and classified by the ECHO (extraction and classification of homogeneous objects) method of automatic supervised classification using ENVI software. Vegetation covered 49% of the total area of the district. It was possible to identify the green areas (a park, five squares, and three *Jardinetes*) and street trees. The green areas represented 9% of the district's total area; 86% of the green areas was covered by vegetation and 14% by impermeable areas (buildings and pavement). It was estimated that the street trees occupied 9% of the district's total area. The results indicate that identification and quantification of urban forests through high spatial resolution digital images are possible.

Towards an understanding of shifting cultivation systems as a form of forest degradation. Morales, L. (*Bangor University, Costa Rica; moralesluciacr@gmail.com*).

There is an important debate on how to deal with land cleared for shifting cultivation (from the REDD+ perspective), particularly regarding whether it should be considered deforestation or forest degradation. Land cover change detection analysis is usually carried out based on satellite data from two different dates several decades apart, which does not allow detection of land-cover dynamics of shorter time periods, or it is done with coarse resolution data. This work aims to quantify carbon stocks in a system of forest clearance and re-growth caused by shifting cultivation, using the Ayuquila Basin in Jalisco as a case study. Multi-date analysis of SPOT 5 satellite imagery was used to estimate the magnitude of the area under shifting cultivation for three years (2004, 2007, 2010). Aboveground biomass was spatially modeled based on the combination of spectral indexes and 106 field data plots, and this relation was used to estimate gain and loss of carbon stocks. Preliminary results indicated that shifting cultivation represents a temporal loss of stocks, which should be monitored according to its temporal and spatial dimensions.

A new European climate data set. Moreno, A., Hasenauer, H. (*University of Natural Resources and Life Sciences (BOKU), Austria; adammoreno@live.com; hubert.hasenauer@boku.ac.at*).

Climate data are essential for performing a wide variety of modeling exercises. Even with the formation of the European Union there still does not exist a cohesive weather station network throughout all of Europe. Individual interpolation over the entire continent is consequently difficult. The European Climate Assessment and Dataset team has compiled data from many of the weather stations throughout Europe to create a gridded daily meteorological data set called E-OBS. This data set, however, is at 0.25 degrees (about 30 km) at its finest grain. A 900-km^2 resolution is not low enough to perform many local, regional, or even landscape-level modeling studies. The authors are using E-OBS along with the climate surface map WorldClim and the algorithm MtClim to produce a daily 1-km^2 resolution data set that covers all of Europe for the time period 1950–2013. Precipitation, maximum temperature, minimum temperature, mean daily temperature, vapor pressure deficit, and solar radiation will be

included. Scientists will now have access to finer-scale meteorological data that are consistent across all of Europe. This data set will eventually be used to create continental-scale modeling simulations on a fine resolution that should improve estimates of European net primary productivity and carbon dynamics.

Comparison of height-diameter mathematical models for three subtropical forest types in southern Brazil. Moser, P., Piazza, G., Vibrans, A., de Maçaneiro, J., Oliveira, L., Lingner, D. (*Regional University of Blumenau, Brazil; paolo.moser@gmail.com; guinuzaum@gmail.com; acv@furb.br; jpmacaneiro@gmail.com; laiozoliveira@gmail.com; deboravanessa.ef@gmail.com*).

Generic height-diameter models were calibrated to predict the total height of tree species in three forest types in Santa Catarina state (southern Brazil), as well as specific models for the species *Nectandra megapotamica* (Spreng.) Mez, *Ocotea puberula* (Rich.) Nees, *Cedrela fissilis* Vell., *Clethra scabra* pers., *Hieronyma alchorneoides* Allemão, *Miconia cinnamomifolia* (DC.) Naudin, *Nectandra oppositifolia* Nees, *Pera glabrata* (Schott) Poepp. ex Baill., and *Tapirira guianensis* Aulb. The data set was collected by the Santa Catarina Forest and Floristic Inventory (IFFSC) in 418 permanent sample plots. The models were calibrated for two databases, one containing the tree heights measured with a hypsometer and the other estimated by field crews. In order to compare these data sets the F test for model identity ("extra sum of squares") was conducted, revealing that the differences between the two data sets are insignificant. Differences in height-diameter relationships between forest types were investigated through the construction of simultaneous confidence intervals using dummy variables and confidence bands generated by the Working-Hotelling method. All inferences were conducted at the level of $\alpha = 0.05$. Differences could be explained by structural and floristic variations, as well as different climatic and geomorphological conditions.

Detectable differences in carbon stocks of forest soils in Japan: Boosted regression tree analysis can identify stratifying factors. Nanko, K., Miura, S. (*Forestry and Forest Products Research Institute, Japan; knanko@affrc.go.jp; miura@ffpri.affrc.go.jp*), Ugawa, S. (*Kagoshima University, Japan; ushin@agri.kagoshima-u.ac.jp*), Hashimoto, S., Osone, Y., Ishizuka, S., Sakai, Y., Tanaka, N., Takahashi, M., Kaneko, S. (*Forestry and Forest Products Research Institute, Japan; shojih@ffpri.affrc.go.jp; osone@affrc.go.jp; ishiz03@ffpri.affrc.go.jp; yoshimis@ffpri.affrc.go.jp; nagaharu@ffpri.affrc.go.jp; masamiti@affrc.go.jp; kanekos@affrc.go.jp*).

Determining changes in soil carbon stocks is an important aspect of global warming countermeasures, but the spatial heterogeneity of forest soils makes them difficult to describe with confidence. Soil C pools were sampled in 2 500 systematically located forested locations in Japan in 2006–2010. Soil C to a depth of 30 cm averaged 6.94 kg C/m^2; dead wood and litter accounted for 0.42 and 0.49 kg C/m^2. Based on a power analysis, the detectable difference in a future remeasurement for this sample size was 3.0, 8.9, and 4.6%, respectively. The number of samples required to detect a 5% change was 875, 7 734, and 2 092. Environmental factors determining soil organic C stocks were analyzed using boosted regression trees. The most important factors were mean annual temperature, slope, and forest type. Sites with colder temperatures and lower slopes had higher soil C contents. Steep slopes were associated with greater rock volume. Stratifying the data set based on these factors will reduce the detectable differences in the 5-year re-survey of these sites. Power analysis can save labor and time in detecting changes in carbon stocks in forest soils with known confidence.

Site quality and climate factors in stand level modeling of biomass growth of hybrid poplar in southern Scandinavia Nielsen, A., Nord-Larsen, T., Stupak, I. (*University of Copenhagen, Denmark; atn@life.ku.dk; tnl@life.ku.dk; ism@ign.ku.dk*), Raulund-Rasmussen, K. (*Forest and Landscape Denmark, Denmark; krr@life.ku.dk*).

The interest in the potential role of poplar biomass production for renewable bioenergy is increasing in southern Scandinavia. The production potential of the OP42 hybrid poplar clone (*Populus tricocarpa x P. maximowiczii)* might be as high as 15 oven-dried tons/ha/yr under south Scandinavian conditions, and the clone has great flexibility under the applied management regime. However, precise knowledge about its growth is required to compare production potential with that of other tree species. This study established a single-tree biomass growth model for the OP42 clone, based on sampling of 50 trees in 7 stands in Denmark and southern Sweden. The model predicts the total aboveground biomass and the distribution of biomass to different tree components, with tree diameters and heights as independent variables. Twelve stands representing a wide range of growth conditions were measured to establish diameter distributions and diameter-height relationships for scaling up the model to stand level. The effect of soil water and nutrient regimes and climatic parameters on stand-level growth was studied. The modeling concept was discussed as a generic approach for inclusion of site factors in biomass growth models.

Long-term forest planning with consideration of fragmentation. Öhman, K., Korosuo, A. (*Swedish University of Agricultural Sciences, Sweden; karin.ohman@slu.se; Anu.Korosuo@slu.se*).

Forest planning is no longer planning for only timber production. Other aspects, such as forest fragmentation, are now included in the planning process. One way to take fragmentation into consideration in forest planning models is to use the core area concept. A core area can be defined as the portion of a stand that is not influenced by effects from surrounding areas, and it is a function of the size, shape, and condition of the stand and the state of the surrounding areas. The objective of this study was to present a new formulation for including core area demands in a traditional forest planning problem where the problem still could be solved with exact solution methods. The formulation includes options for varying the edge effect. The model was applied in a case study for a landscape in northern Sweden in the context of reindeer husbandry. In the study the core area concept was used to increase the connectivity between reindeer grazing areas. Preliminary results from the case study show that it is possible to increase connectivity at a relatively low cost. However, the cost largely depends on how the reindeer grazing areas are defined.

Geoprocessing in creating maps for the purpose of conservation areas in a state park in Brazil. Oliveira, F.B., Oliveira, C. R., Lima, J., Miranda, M.R., Filho, R.B.R. (*Espírito Santo State University, Brazil; fabriciabenda@gmail.com; engcarloshenrique@yahoo.com.br; juliao.lima@ufes.br; maiararm123@gmail.com; reinaldobrfilho@gmail.com*), Ferraz, F. (*Faculdades Integradas de Aracruz, Brazil; fillipe.ferraz7@gmail.com*), Turbay, E.R.M.G. (Capixaba Institute of Research, Technical Assistance and Rural Extension*; emunaro@hotmail.com*).

The Cachoeira da Fumaça State Park in the state of Espírito Santo, Brazil, has an approximate area of 162.50 ha. This study developed a procedure to assist managers in making decisions about the allocation of conservation areas, using multiple criteria analysis and GIS techniques to generate thematic maps that define areas suitable for conservation. Seven factors relevant to conservation suitability were prioritized using the Analytic Hierarchy Process. After these factors were combined, a map was generated showing areas that ranged in suitability from less to more in need of conservation. Through analysis of the map, strategies for conservation of the park can be developed in order to concentrate efforts on more vulnerable areas, thus guiding the work of managers and saving resources. It was observed that the areas most in need of conservation measures are mainly close to the waterfall and park structures because of increased anthropogenic pressure exerted at these locations. Other vulnerable areas were grazing areas in the regeneration stage.

Comparison of methodologies for quantifying deforestation: a case study in Chico Mendes Resex, Brazilian Amazon. Oliveira, K. (*University of Viçosa, Brazil; kamillarbr@gmail.com*), Bomfim, B. (*University of California Davis, USA; bdbomfim@ucdavis.edu*), Soares-Filho, B.S. (*Federal University of Minas Gerais, Brazil; britaldo@csr.ufmg.br*), Emiliano, P.C. (*Federal University of Viçosa, Brazil; paulo.emiliano@ufv.br*), Pereira, R.S., Matricardi, E.T. (*University of Brasília, Brazil; reginaldosp@unb.br; ematricardi@gmail.com*).

The Chico Mendes Extractive Reserve (RESEX), historically known for environmental disputes with regard to its preservation, was used as a case study for comparing methodologies in quantifying deforestation in Acre State, Brazil. Two methods were used to quantify deforestation between 1989 and 2010: PRODES, developed by the Brazilian National Space Institute (INPE), and a method developed by the Geoprocessing Unit (UCEGEO) in Acre. According to the longest temporal series (mapped by UCEGEO) for the study area, the accumulated gross deforestation was 7 174.14 ha in 1988. Between 1989 and 2010, the mean deforested area increased by 2 295.67 ha/yr, from 0.077% of the total area in 1988 to 0.5% of the total area by the end of 2010. This represented an increase of 57 672 ha in deforested areas, accounting for 0.33% of the deforestation in Acre. Results of the accuracy analysis showed that UCEGEO overestimated by nearly 4.9% (87.34 ha) the value classified and validated by the high-resolution Formosat image, and PRODES underestimated it by 16.8% (–297.9 ha). Analysis of classification accuracy found that PRODES showed lower ability to distinguish between classes, whereas the UCEGEO method was more accurate in classification.

Research Infrastructure & Network for Monitoring and Adapting European Atlantic Forests under Climate Change (REINFFORCE). Orazio, C. (*European Forest Institute, France; christophe.orazio@efi.int*), Carnus, J. (*Institut National de la Recherche Agronomique, France; carnus@pierroton.inra.fr*), Cordero-Debets, R. (*European Forest Institute, France; rebeca.cordero-debets@efi.int*).

As climate change is a global and long-term issue, there is a need to coordinate and develop transnational research infrastructures to investigate adaptive forest management options and to provide harmonised monitoring data on effects of rapidly changing climates on forest ecosystems. Approaches through ecophysiological studies or bioclimatic envelopes have their limitations. Therefore, planting the same tree genetic materials under a wide range of climates and continuously monitoring climatic impact on those trees seems a relevant tool to study species' responses to future climates. Such an infrastructure of "climate change arboreta" has been established in Atlantic Europe over a large climatic gradient (Mediterranean to boreal) and will offer opportunities for identifying specific climatic parameters affecting selected tree species, and for screening of variability of various provenances. This network of arboreta mainly addresses selection of reproductive material for planting, but the infrastructure also includes large-scale forest demonstration sites where different adaptive management options are tested in the field and compared to business-as-usual management. The research infrastructure (REINFFORCE) provided the opportunity to launch a European database on long-term monitoring trials with a map and species tested that can be consulted at http://www.efiatlantic.efi.int/portal/databases/forestrials/.

Effects of climate change on suitable habitat of trees; analysis in two ecoregions. Osorio, C. (*Independent, Peru; marcela.mosorio@gmail.com*), Gunter, S. (*Thünen Institute of International Forestry and Forest Economics, Germany; sgunter@catie.ac.cr*).

The main objective of this research was to evaluate the effect of climate change scenarios on changes in suitable habitat of 26 tree species of priority conservation or timber value, at the regional level with an emphasis on Costa Rica. Climatic and physiographic variables were considered, data came from herbal botanicals, and current and future projection (to 2020) was performed with the program MaxEnt. The results show loss of suitable habitat from 24% for trees with timber value to 44% for species with conservation value. Effect of climate change differs by ecoregion; loss of suitable habitat is less severe in the north than in the south. Furthermore, suitable habitat loss within protected areas and biological corridors is very similar to the total, suggesting that establishment of these areas will not effectively mitigate habitat reduction. The main conclusion is that conservation strategies should consider specific effects within each ecoregion and also should consider a set of biological corridors as a possible approach to potential migration routes. The method can be a useful tool for other adaptation measures such as selecting seed sources and planning for forest plantations.

Estimating aboveground biomass using airborne LiDAR in tropical seasonal forests for REDD+ implementation. Ota, T., Kajisa, T., Mizoue, N., Yoshida, S., (Kyushu University*, Japan; chochoji1983@gmail.com; kajisa@agr.kyushu-u.ac.jp; mizouenn@gmail.com*, *gm.syoshida@gmail.com*), Takao, G., Hirata, Y., Furuya, N. (*Forestry and Forest Products Research Institute, Japan; takaogen@ffpri.affrc.go.jp; hirat09@affrc.go.jp; nfuruya@affrc.go.jp*), Sano, T. (*Asia Air Survey Co., Ltd, Japan; tk.sano@ajiko.co.jp*).

The objectives of this research were to: (1) develop an empirical model to estimate aboveground carbon density with variables derived from airborne LiDAR in tropical seasonal forests in Cambodia, and (2) assess the effect of pulse density of airborne LiDAR on the estimation accuracy of aboveground carbon density. First, the relevance of variables to estimate aboveground carbon density from original pulse density data was checked. Aboveground carbon density was regressed against eight variables

derived from airborne LiDAR. Then, the relationship between pulse density and estimation accuracy was investigated using the best regression model. The accuracy of the model from eight LiDAR point densities consisting of 0.25, 1, 2 3, 4, 5, and 10 pulses/m^2 was compared. Mean canopy height (MCH) derived from airborne LiDAR was highly correlated with aboveground carbon density. The best model was the single MCH model (R^2 = 0.97). Additionally, the differences in RMSE between each pulse density were less than 1 Mg/ha. The main conclusion is that aboveground carbon density can be estimated from MCH derived from airborne LiDAR in tropical seasonal forests in Cambodia even when using data from a pulse density of 0.25 pulses/m^2.

Using species distribution models to select climate change-resistant species for ecological restoration of bowé in West Africa. Padonou, E. (*University of Abomey-Calavi, Benin; padonouelie@yahoo.fr*), Bachmann, Y. (*J.W. Goethe University, Germany; bachmann@bio.uni-frankfurt.de*), Sinsin, B. (*University of Abomey-Calavi, Benin; bsinsin@gmail.com*).

Bowalization is a particular form of land degradation and leads to lateral expansion of ferricrete horizons. The process occurs only in tropical regions. In this study the species most adapted and resistant to climate change were identified on *bowé.* The 15 most common *bowé* species of the sub-humid and semiarid climate zones of Benin were submitted together with significant environmental variables (elevation, current bioclimatic variables, soil types) to the ecological niche modeling program Maxent (version 3.3.3). For future prediction (2050) IPCC4 climate data from the International Center for Tropical Agriculture were applied. *Asparagus africanus, Andropogon pseudapricus*, and *Combretum nigricans* were identified as the most resistant species for ecological restoration of *bowé* in the semiarid climate zone and *Asparagus africanus, Detarium microcarpum*, and *Lannea microcarpa* in the sub-humid climate zone.

The impact of climate change on *Eucalyptus globulus* plantation productivity: Bayesian model averaging of two process-based models. Palma, J., Minunno, F. (*Technical University of Lisbon, Portugal; joaopalma@isa.ulisboa.pt; francescom@isa.utl.pt*).

Both 3PG and YIELDSAFE are forest process-based models. While 3PG is being used worldwide due to its simplicity, YieldSAFE, being even more parameter sparse, is more specific to agroforestry systems, and includes water and light competition algorithms between the tree component and the understory (e.g., pasture, agricultural crops). It has been suggested that 3PG could include competition from the understory. This work explored the possibility of taking advantage of having a previously developed model with understory competition algorithms. By means of Bayesian statistics, the two models were calibrated for *Eucalyptus globulus* stands in Portugal, using a comprehensive data set that consisted of eddy-covariance fluxes, experimental plots, and permanent sample plots. Independent data were used for the Bayesian model comparison of the two models. Taking into account the uncertainty in model selection, the Bayesian model averaging was used to make predictions about the impact of climate change on *E. globulus* productivity. Results showed how the most productive regions of the country are more vulnerable to changes in climatic conditions.

Integrating a forest ecosystem services finder in WEFES, a Web-based explorer for forest ecosystem services. Palma, J. (*Technical University of Lisbon, Portugal; joaopalma@isa.ulisboa.pt*), Payn, T. (*Scion, New Zealand; tim.payn@scionresearch.com*).

Central to any land use decision-making is the need for information, data, models, and knowledge. As long as the complexity of need expands, the difficulty of providing, managing, and manipulating such knowledge expands with it. Web 2.0 developments—Web applications that facilitate participation, information sharing, interoperability, and collaboration, and that are user-centered—opens up the opportunity to use data in ways previously impossible and to develop systems and approaches that will allow users to work in different ways. In 2009 an international collaborative project 'TRANZFOR' (www.tranzfor.eu) developed the Web Explorer of Forest Ecosystems Services under climate change (WEFES) to identify forest productivity and ecosystem services at a forest location and evaluate the impact of climate change. A recent development, Forest Ecosystems Services Finder (FESF), uses a reverse approach in WEFES. Users can now search for specific levels of ecosystem services and productivity mixes on the map, allowing the identification of locations with higher combined benefits, such as erosion control and reduction of nitrate leaching. Identification of priority areas for afforestation is thereby facilitated. Web 2.0 approaches have helped users avoid the need to access large and complex software systems, thus increasing the accessibility of complex information. The WEFES tool is available at http://home.isa.utl.pt/~joaopalma/projects/tranzfor/wefes.

Biodiversity monitoring for sustainable conservation of Mt. Makiling Forest Reserve and Mt. Banahaw to support regional food security and monitor climate change impacts. Pampolina, N. (*University of the Philippines, the Philippines; nelsonmanguiatpampolina@yahoo.com*).

Establishment of permanent biodiversity monitoring areas (PBMA) is essential to generate research useful in coding genes of plants that show potential as food and to indicate local climate change. This paper presents a GIS based of data management to monitor biodiversity in plots set from ASEAN Heritage Mt. Makiling Forest Reserve and Mt. Banahaw, a home to several new species. The main objective was to characterize and identify potential biodiversity resources from these mountains that will address food security and provide ecophysiological evidence of climate change. A 2-ha PBMA was permanently gridded following international standards. Composition, biometrics, and structure of floristic taxa, wildlife vertebrates and invertebrates, and fungal resources are being surveyed for geospatial data and identification, and, in the case of plants, for a herbarium collection. Plant species exhibiting food qualities will be sampled via microtechniques to determine fiber biometrics and other measurements. Chemical analysis for protein, sugar, and anti-oxidant properties will be obtained using gas chromatography and other techniques. Diversity parameters in relation to climate change will include allelic richness, private alleles, observed heterozygosity, unbiased heterozygosity, and inbreeding depression coefficient. All parameters will be statistically tested and considered as a basis for food production in a suitable ecosystem while conserving the natural genetic pool.

Forest management and carbon regulation: an integrated economic perspective based on sequestration, storage, and substitution. Peyron, J. (Ecosystèmes Forestiers (*ECOFOR), France; jean-luc.peyron@gip-ecofor.org*).

Carbon issues play a major role among the challenges that forestry faces. They depend on many phenomena such as the sequestration of CO_2 in stands and soils by growing forests, the residence time of carbon in forests and wood products, land use changes, the substitution of wood for materials that release large carbon emissions when they are processed, and the use of wood fuel instead of fossil fuel. Due to these various aspects, carbon issues cannot be addressed easily from a management point of view and are highly controversial. There is probably a need for a reference: an integrated carbon indicator that takes into account forest management and forest-based products. The framework of economics allows the comparison of different alternatives based on multiple phenomena considered at different periods. This presentation clarifies the main phenomena determining carbon management in forests. It then aims to discuss each of them separately in order to determine how they should be accounted for and to identify which assumptions should be stated. It finally tells how an integrated indicator could be a reference for carbon management and complement the reference used for roundwood production over time.

Monitoring trends and burn severity for the United States. Quayle, B., Megown, K., Finco, M., Schwind, B., Lecker, J. (*U.S. Forest Service, USA; bquayle@fs.fed.us; kamegown@fs.fed.us; mfinco@fs.fed.us; bschwind@fs.fed.us; jlecker@fs.fed.us*).

The Monitoring Trends in Burn Severity (MTBS, www.mtbs.gov) project is mapping the extent, size, and severity of all large fires greater than 1 000 acres in the West and 500 acres in the east over the conterminous United States (CONUS), Alaska, and Hawaii. In 2012 the project reached a milestone, completing the mapping for all fires between 1984 and 2010. The MTBS project produces geospatial and tabular data using a consistent protocol for fire trend analysis at a range of spatial, temporal, and thematic scales. This paper reviews the objectives of the MTBS project, describes the data sets and information provided, and presents results of the analysis of the 1984–2010 MTBS data set for the United States.

In situ conservation of an urban forest fragment in the Botanical Garden of Salvador, Brazil. Queiroz, E., Souza dos Santos, L. (*Botanical Garden of Salvador, Brazil; eripqueiroz@yahoo.com.brlusozah@yahoo.com.br*), Andrade, P.M. (*Federal University of Bahia, Brazil; pedroematos@hotmail.com*), Kucharski, C., Teixeira, L. (*Botanical Garden of Salvador, Brazil; chenriquegaspar@hotmail.com; lucineide-teixeira@ibest.com.br*).

Urban forests have an essential function in the well-being of cities because of their environmental services and maintenance of biodiversity. The Brazilian Atlantic Rainforest in Bahia is recognized worldwide as a hotspot of biodiversity. Botanical gardens play a fundamental role in the conservation of biodiversity, environmental research, and education. Located in a rapidly developing coastal city, the Botanical Garden of Salvador (BGS) has a special urban forest fragment (17 ha), locally known as Mata-dos-Oitis, because of the presence of an endemic species, *Licania salzmannii*. BGS harbors many endemic and threatened species, such as *Hirtella insignis, Cattylea* spp., and *Dalbergia nigra*, some of which are rare and are indicators for preserved areas. Since its establishment in 2002, BGS has contributed to the conservation of the rain forest by studying floristic composition, phytosociology, and plant development; applying specific management methodologies; monitoring pilot areas; containing the edge effect; adding tree species; assessing forest health; surveying and gradually replacing exotic species with native species; identifying and controlling invasive species; producing forest seedlings; and raising the surrounding population's awareness about conservation of native forest species. Through this conservation activity, there have been a significant enrichment of species and an increase in vegetation cover in edge-effect areas.

Forest aboveground biomass estimates in Madagascar: new insights from the use of wood specific gravity data. Rafidimanantsoa, H., Ramanakoto, M., Ramananantoandro, T. (*Université d'Antananarivo, Madagascar; rafidimanantsoa.patrick@gmail.com; miorra_mi@hotmail.fr; ramananantoandro@gmail.com*).

To generate carbon credits under REDD+, accurate estimates of forest carbon stocks are needed. Carbon accounting efforts have focused on carbon stocks in aboveground biomass (AGB). Although wood specific gravity (WSG) is known to be an important variable in AGB estimates, there is currently a lack of data on WSG for Malagasy tree species. This study aims to determine whether estimates of carbon stocks calculated from literature-based WSG values and WSG values measured from wood core samples differ. Carbon stocks in forest AGB were assessed using two WSG data sets: (1) WSG values measured from 3 250 wood core samples extracted in the study area, and (2) WSG values derived from two existing databases (Zanne *et al*., 2009, Vieilledent *et al*., 2012). Results suggest that carbon stocks calculated from the two data sets do not significantly differ at the level of $\alpha = 0.05$ level despite the significant difference between the field and literature-based WSG values. Such findings could be attributed to the form of the allometric equation used. The choice of data set should depend on the level of accuracy (TIER II or III) desired within REDD+. As higher levels of accuracy are rewarded at a higher price, species-specific AGB and WSG data would be highly desirable.

Estimation of tree radial growth in the South Western bushes of Madagascar by growth ring analysis. Ramananantoandro, T. (*Université d'Antananarivo, Madagascar; ramananantoandro@gmail.com*), Beeckman, H. (*Royal Museum for Central Africa, Belgium; hans.beeckman@africamuseum.be*), Heriniaina, R. (*Université d'Antananarivo; vonenina@gmail.com*), Josoa, R.R. (*Université d'Antananarivo, Madagascar; rramarolanonana@yahoo.fr*).

There are few data on the growth of Malagasy native species, especially drought-resistant bushes in the bush ecosystem, which is rich in biodiversity. Yet these ecosystems are subject to high pressures from slash and burn agriculture and charcoal production. Deforestation is estimated at more than 1% per year. The absence of reliable data on forest productivity implies that the development of management plans is currently based on unverified assumptions of growth in diameter estimated as 2–3.3 mm/yr. This work aimed to estimate the annual radial growth of the most abundant species in the bush ecosystem in South Western Madagascar by growth ring analysis. The study focused on seven common species: *Alluaudia comosa, Cedrelopsis grevei, Gyrocarpus americanus, Poupartia caffra, Rhigozum madagascariense, Sclerocarpa birrea*, and *Terminalia gracilipes*. Five trees per species were harvested. The growth rings of disks taken at 30 cm from the ground level were analyzed anatomically, then counted and

compared with rainfall data. Results showed that it is possible to identify growth rings on these seven species. The annual diameter growth rate ranges between 0.58 and 1.81 mm/yr, which is lower than the hypothesis. These data are crucial to estimate accurately woody biomass productivity of this ecosystem to be compared with the wood extraction rate.

Research strategies for genecological zonation of teak in India. Ramasamy, Y. (*Institute of Forest Genetics and Tree Breeding, India; yasodharaja@yahoo.com*).

India is one of the world's largest consumers of timber products and a major importer of timber. The demand for timber in India is expected to grow to 153.0 million m^3 by 2020. Although India is recognized as one of the main centers of diversity for teak, all the logs consumed in India are now imported and it remains the biggest market. Genetic resources for teak are shrinking in the country because of illegal felling and habitat destruction. Further, climate change projections show that 30% of the teak growing area in India is vulnerable. Assessment of morphological, genetic, and ecological characteristics of teak should be considered to address more complex demographic questions, such as the sizes of subpopulations, their degree of substructure, and rates of gene flow. Identification of a deficit of rare genetic variants may suggest population contraction, which would be the result of recent illegal harvesting of the best phenotypes. Identification of substructure if any within populations may influence breeding strategies. In addition, such data can play an important role in the management and conservation of species. These efforts are particularly important in light of the distribution status of teak and the increasing isolation of teak populations caused by habitat fragmentation and decline.

Effect of field plot location on estimating tropical forest attributes of Nepal using airborne laser scanning (ALS) data. Rana, M., Tokola, T., Korhonen, L. (*University of Eastern Finland, Finland; parvez.rana@uef.fi; timo.tokola@uef.fi; lauri.korhonen@uef.fi*).

Prediction of tropical forest attributes using airborne laser scanning (ALS) is becoming attractive as an alternative to traditional field measurements for providing accurate estimates. Area-based ALS inventories require a set of representative field sample plots from the study area, which may be difficult to obtain in tropical forests with limited accessibility. The study investigates the effect of sample-plot selection based on accessibility factors in mountainous Nepal. The authors assumed that the estimation error increases if the plots are placed in sloping areas or farther away from the road. The optimal number of training plots was also tested. The sparse Bayesian regression method was used in the model to estimate forest variables with a leave-one-out cross validation procedure for model validation. Study findings showed that the estimation error of stem volume and aboveground biomass increased with increasing field plot distances from the road. The paired-sample Wilcoxon signed-rank test proved that the reduced number of sample plots provided statistically similar performance compared with the full data set. The one way analysis of variance test confirmed that sample-plot distances had significant correlation with stem density. These outputs strengthen the authors' assumption that the field plots farther away from road had low accuracy, which could be related to the high stem density.

A new concept for biomass estimation of conifer-dominated boreal forest using remote sensing data. Rana, M., Tokola, T., Korhonen, L., Xu, Q., Kumpula, T. (*University of Eastern Finland, Finland; parvez.rana@uef.fi; timo.tokola@uef.fi; lauri.korhonen@uef.fi; Qing.xu@uef.fi; timo.kumpula@uef.fi*), Vihervaara, P., Mononen, L. (*Finnish Environment Institute, Finland; petteri.vihervaara@ymparisto.fi; laura.mononen@ymparisto.fi*).

This study evaluated the accuracy of boreal forest aboveground biomass (AGB) estimates obtained using airborne laser scanning (ALS) and RapidEye data in a two-phase sampling method. Linear regression-based estimation was tested using an independent validation data set and the performance was evaluated by assessing the bias and RMSE. In phase I, ALS data from 50 field plots were used to predict AGB for the 200 surrogate plots. In phase II, the ALS-simulated surrogate plots were used as a ground-truth to estimate AGB from the RapidEye data for the study area. The resulting RapidEye models were validated against a separate set of 28 plots. The RapidEye models showed a promising accuracy with a relative RMSE of 19–20% for AGB. The evaluated concept of biomass inventory would be useful to support future forest monitoring and decision-making for sustainable use of forest resources.

Terra-i: an initiative to monitor forests and other natural covers based on the use of geospatial tools. Reymondin, L., Coca Castro, A., Tello, J., Paz, P., Navarrete, C., Jarvis, A. (*International Center of Tropical Agriculture, Colombia; terra.i.ciat@gmail.com; a.coca@cgiar.org; J.J.TELLO@cgiar.org; paulapaz1101@gmail.com; c.navarrete@cgiar.org; a.jarvis@cgiar.org*), Mulligan, M. (*King's College London, United Kingdom; drmarkmulligan@gmail.com*), Perez-Uribe, A. (*University of Applied Sciences Western Switzerland, Switzerland; Andres.Perez-uribe@heig-vd.ch*).

"Terra-i: An eye on habitat change" is a monitoring system in near real time that detects habitat changes over Latin America and the Caribbean with a spatial resolution of 250 m and temporal resolution of 16 days. The tool, which generates predictive models supported by the use of neural networks and satellite data, is able to detect, from 2004 to the current year, anomalies from the typical natural cycle of vegetation that can be associated mostly with anthropogenic impacts. The data generated allow the determination of when, where, and how often the region is experiencing the most common events of change, especially deforestation and the loss of other natural covers. Comparison of data with other regional systems such as PRODES-Brazil and GUYRA-Paraguay provides evidence that Terra-i approximates the values reported by those models for tropical and subtropical habitats. Additionally, Terra-i data have been integrated into decision support systems such as WaterWorld and Co$ting Nature to understand the impact of coverage change on hydrology as well as on the production and delivery of ecosystem services. Finally, the tool, with its flexible and automated methodology, has the potential and is projected to extend its monitoring throughout the entire Tropics.

Impacts of biomass operations on soil erosion. Rhee, H. (*University of Montana, USA; hakjun.rhee@gmail.com*), Elliot, W., Miller, I. (*U.S. Forest Service, USA; welliot@fs.fed.us; suemiller@fs.fed.us*).

This study aimed to investigate the impacts of different biomass operations on water resources. Three field sites were selected that used different biomass operation methods: the Payette National Forest (in the state of Idaho, USA) using forwarder, the Colville

National Forest (state of Washington) using tractor and skidder, and the Flathead National Forest (state of Montana) using skyline. A total of 47 silt fences (5 m × 10 m) were installed to monitor soil loss from biomass operations during the first few years after the operations; 28 silt fences were on the disturbed plots, and 19 on the control plots. No soil loss was observed except on the forwarder trails in the Payette National Forest, where animal disturbances (deer, elk, and gopher) were responsible for the soil losses. Infiltration rates measured using an onsite infiltrometer showed that rates on the on-trail plots for the ground-base operations were lower than on the control plots. Vegetation cover increased on the disturbed plots, but it remained the same on the control plots. Current data indicate no direct impacts on water resources attributable to biomass operations. However, pulverized road conditions, a potential source for soil erosion, were observed in the Payette National Forest, due to an increase in traffic volume for transporting biomass feedstock.

Characterization of fire regimes in Utah's subalpine forests using remotely sensed data. Rhodes, A., Horn, K., St. Clair, S. (*Brigham Young University, USA; aaron.rhodes0@gmail.com; 3horns@byu.net; samuel_stclair@byu.edu*).

Fire drives ecological processes on a global scale, defines plant community composition, and delineates regional biomes. Fire is what has driven the functionality of many ecosystems across geological time; it gives rise to spatial and biologic patterns on the landscape. The variability in fire regime characteristics has important consequences for regeneration of flora and fauna across landscapes. Despite the recognized importance of fire regimes, it remains uncharacterized in much of the world. The authors' objective was to develop a clear understanding of regional fire regimes in the subalpine forests of the state of Utah, USA. Landsat imagery from 1974 to present was used to derive normalized burn ratios to estimate severity, extent, and frequency of fire. The following themes were explored: (1) The fire regimes of the dominant vegetation types (aspen dominant, aspen-conifer mixed, and conifer dominant) were examined differentially based on classification under the Gap Analysis Program (GAP) from 1995. (2) In order to examine the effects of climate, topography, and human land use, those parameters were modeled using GIS as explanatory variables of fire regimes. (3) In order to characterize fire regimes as a function of topography, digital elevation models were used to extract slope, aspect, and elevation. Those variables were then modeled as explanatory parameters for a region-wide fire model.

Using financial indicators to manage risk in timber supply modeling. Rodriguez, G., Raulier, F. (*Laval University, Canada; gereroba@gmail.com; Frederic.Raulier@sbf.ulaval.ca*).

Risk analysis entails systematic use of historical information to determine frequency of unexpected events such as wildfires and the magnitude of their consequences. Currently forest management is based on long-term sustained timber yield, predicted with deterministic planning models. This study used financial indicators to manage risk in timber supply models. These indicators are based on the cumulative probability distributions of potential supplies: upside potential or opportunity value and the risk area ratio. The methodology was applied to a 1.08 million-ha forest management unit in the eastern Canadian boreal forest in the context of supply planning and harvest scheduling. The Spatially Explicit Landscape Event Simulator (SELES) was used to simulate the interaction between harvest planning and stochastic processes such as fire over time. The authors explored the effects of accounting for fire risk under the ecosystem-based management strategy and made comparisons with the business-as-usual strategy. Decision-making was improved with the use of this methodology, which accounts for uncertainties.

Comparing probability-proportional-to-size and simple random sampling designs in model-assisted estimation of growing stock in a boreal forest area in Finland. Saarela, S. (*University of Helsinki, Finland; svetlana.saarela@helsinki.fi*), Grafström, A., Staahl, G. (*Swedish University of Agricultural Sciences, Sweden; Anton.Grafstrom@slu.se; goran.stahl@slu.se*), Kangas, A., Holopainen, M. (*University of Helsinki, Finland; annika.kangas@helsinki.fi; markus.holopainen@helsinki.fi*), Tuominen, S. (*Finnish Forest Research Institute (METLA), Finland; sakari.tuominen@metla.fi*), Nordkvist, K. (*Swedish University of Agricultural Sciences, Sweden; Karin.Nordkvist@slu.se*), Hyyppä, J. (*Finnish Geodetic Institute, Finland; juha.hyyppa@fgi.fi*).

Airborne laser scanning (ALS) and satellite optical data for use in large-area forest inventories were evaluated with the intent to increase estimation accuracy and decrease costs. The aim of the study was to efficiently use both wall-to-wall satellite optical data and a sample of laser scanning data using model-assisted sampling to estimate the volume of growing stock. Variables derived from the Landsat ETM satellite image were spectral values of blue, green, and red lights, near infra-red (IR), and two shortwave IR channels. From the laser scanning data 26 laser scanning height- and density-based features were extracted. The study was performed in a 30 000-ha area of Kuortane, western Finland. Sample plots, measured using a modification of the 10th National Forest Inventory, were used as field data. Three nonlinear regression models were developed and analyzed. Different sample sizes and uses of auxiliary information in connection with the model-assisted estimation were compared. Results showed that Landsat-based wall-to-wall auxiliary data improve the estimation accuracy compared to using only ALS sample data. Probability-proportional-to-size sampling of ALS strips in the first phase (and simple random sampling in the second) was shown to be more efficient than using simple random sampling in both phases.

Forest carbon stocks in longleaf pine forests in the southern United States. Samuelson, L., Stokes, T. (*Auburn University, USA; samuelj@auburn.edu stoketa@auburn.edu*), Butnor, J., Johnsen, K. (*U.S. Forest Service, USA; jbutnor@fs.fed.us); kjohnsen@fs.fed.us*), Gonzalez-Benecke, C. (*University of Florida, USA; cgonzabe@ufl.edu*), Anderson, P., Jackson, J. (*U.S. Forest Service, USA; phanderson@fs.fed.us; jajackson@fs.fed.us*), Ferrari, L. (*Auburn University, USA; lzf0012@auburn.edu*), Martin, T., Cropper, W. (*University of Florida, USA; tamartin@ufl.edu; wcropper@ufl.edu*).

Longleaf pine (*Pinus palustris* Mill.) ecosystems in the southern United States offer opportunities to sequester carbon and mitigate CO_2 emissions, because longleaf pine is a long-lived tree species and there is a renewed focus on restoration and protection of longleaf pine ecosystems for a variety of ecosystem services. The authors are developing and linking two longleaf pine forest carbon cycle models: an even-aged plantation model that can simulate scenarios for young (0–50 yr) planted longleaf pine stands and a single-tree-based model which will enable simulation of older (40 to >200 yr) uneven-aged stands. This work will: (1) model the forest carbon cycle of longleaf pine ecosystems based on measurements on three military installations (Georgia, Louisiana, and North Carolina) representing the historical range of the species, (2) elucidate sources and sinks of

carbon and changes through time, and (3) determine the contribution of ecologically based forest management to carbon offsets. To support model calibration and validation, carbon stocks in aboveground and belowground biomass, shrubs, the herbaceous layer, soils, forest floor litter, and detritus were measured in 10 stands (5–87 yr of age). Allometric relationships were developed. Forest carbon stocks were dependent on stand age and structure.

Testing alternative response designs for training forest disturbance and attribution models. Schroeder, T., Moisen, G., Schleeweis, K. (*U.S. Forest Service, USA; tschroeder@fs.fed.us; gmoisen@fs.fed.us; kgschleeweis@fs.fed.us*).

Understanding and modeling land cover and land use change is evolving into a foundational element of climate, environmental, and sustainability science. Land cover and land use data are core to applications such as carbon accounting, greenhouse gas emissions reporting, biomass and bioenergy assessments, hydrologic function assessments, fire and fuels planning and management, and forest and rangeland health assessments. Remote sensing-based monitoring efforts like the North American Forest Dynamics (NAFD) project, and the newly launched Landscape Change Monitoring System (LCMS), will provide land cover and land use change data on all U.S. lands for the longest possible historical period. Empirical models driving disturbance and causal maps rely on large quantities of high quality data. Many decisions need to be made about the size, shape, quantity, quality, and other details about the training plots themselves, i.e., the response design. Here, the authors explored best practices for collecting training data for these empirical models on 10 pilot scenes in the United States. Alternative designs were evaluated in terms of their costs and benefits for national mapping applications.

Global Forest Information Service (GFIS) in Russia. Shalaev, V., Chumachenko, S., Kulakova, O. (*Moscow State Forest University, Russian Federation; shalaev@mgul.ac.ru; chumachenko@mgul.ac.ru; koololka@gmail.com*).

The mission of the Global Forest Information Service (GFIS) in Russia is to disseminate information and knowledge among members of the global forest community. The goal is to give all people whose activities are related to forests and the forest sector, an opportunity to obtain and share information. The GFIS was established in 1998 and began operation in Russia in 2005. In recent years, the Internet portal GFIS.ru for the Russian part of the Global Forest Information Service was developed by Moscow State Forest University as a project within the International Partnership on Forests. Currently the authors are working on filling up the site. News about forests, both in the forestry and broader scientific spheres, is published daily on the Website. Information on upcoming conferences, training, workshops, exhibitions, and other forestry-related events is published regularly by site administrators. Future development of the Website will include efforts to increase the amount of information published and to enhance the features of the digital library. Books, scientific papers, articles, and abstracts will be available in the digital library, and improvements are planned for easier access to and sale of the resources in this depository.

Comparison of land cover classification using medium resolution and high resolution imageries. Shrestha, H. (*Kathmandu University, Nepal; hlshrestha@gmail.com*).

Information about land cover is a fundamental geospatial component that informs the preparation and implementation of land use plans and other decisions about development issues. Remote sensing technology makes an important contribution to the study of land cover and land use change dynamics as past records are lacking in many locations. Remotely sensed images of historical land cover can be compared with data on current land use status. However, as remote sensing technology advances, some technological issues arise when comparing past and present status of land use and land cover. Thus, the aim of this study was to compare the methodological performance of land cover classification by using medium resolution and high resolution imageries from the same date. This comparison gave an opportunity to understand limitations, differences in processing methodologies, and effects on product results. The study showed that land use and land cover can be interpreted in greater detail from high resolution images and at a more generalized level with medium resolution imagery.

MODIS-based forest fire burned area assessment in the Hind-Kush-Himalayan (HKH) region. Shrestha, H. (*Kathmandu University, Nepal; hlshrestha@gmail.com*).

Forest fire is considered to be a major driver of forest degradation through the burning of trees and production of ash and smoke. Burning of forest trees also emits carbon to the atmosphere. Rate of spread of a forest fire depends, in part, on forest type. A forest fire can be described in spatio-temporal terms: when it occurred, rate and degree of spread, and location and extent of burning scars on ground. A geospatial approach can better present the current scenario, assess the damage and losses, and support planning for fire management. MODIS products have the capability to support regular monitoring of forest fire occurrence and losses. This study tried to determine current trends in forest fire occurrence and burned areas in the Hind-Kush-Himalayan (HKH) region from 2000 to the present using MODIS. The study also tried to assess the seasonality and spatiality of the forest. The MODIS MCD45A1 products of burn area and burn date were analyzed by writing the routine code in Python scripting. The HKH region does not have a proper damage assessment and recording system for forest fires. The assessment of active forest fires and burned areas provides the information needed for forest fire management in the region.

A system for assessing live biomass of northern Eurasian forests: methodology, models, results, and uncertainties. Shvidenko, A. (*International Institute for Applied Systems Analysis (IIASA), Austria; shvidenk@iiasa.ac.at*), Usoltsev, V. (*Russian Academy of Sciences, Russian Federation; usoltsev50@mail.ru*), Shchepashchenko, D. (*International Institute for Applied Systems Analysis (IIASA), Austria; schepd@iiasa.ac.at*), Lakyda, P. (*National University of Life and Environmental Sciences of Ukraine, Ukraine; lakyda@nubip.edu.ua*).

This paper presents systems analysis of current methods and models used for assessing live biomass (LB) of temperate and boreal forests. Methods that are based on forest inventory data generate an empirical background for reliable estimation of uncertainties. Grouped by ecoregion, two unified sets of biomass extension factors (BEF) for northern Eurasia forests are presented in forms of multiple regressions: (1) for data aggregated by forest enterprises [BEF = f (DS, A, SI, RS)] and (2) for biometric characteristics of individual stands [BEF = F(TS, A, D, H, N, H100)], where DS = dominant species, A = age, SI = site index, RS = relative

stocking, TS = species composition, D = average diameter, H = average height, N = number of trees, and H100 = expected height at 100 yr. BEF are defined for seven LB components: stems, branches, foliage, coarse roots, fine roots, understory+undergrowth, and green forest floor based on measurements at approximately 8 000 sample plots. At a country level, the system has been applied for forests of Russia and Ukraine. Results were presented in a spatially explicit form. "Within method" uncertainties depend on quality of inventory data and regional accuracy of BEF and are estimated at 5–7% (CI 0.9). The modeling system can be used in integrated observation systems, e.g., for apportioning remotely sensed forest biomass.

Assessing the climate change mitigation potential of residue-based bioenergy in Canada's forest sector. Smyth, C., Rampley, G., Lemprière, T., Kurz, W., Schwab, O. (*Natural Resources Canada, Canada; carolyn.smyth@nrcan.gc.ca; greg.rampley@nrcan.gc.ca; tony.lempriere@nrcan.gc.ca*, *wkurz@nrcan.gc.ca; olaf.schwab@nrcan.gc.ca*).

The potential of the forest sector to mitigate greenhouse gas (GHG) emissions is widely recognized, but challenging to quantify at the national scale. This study determined the mitigation potential of harvest residue-based bioenergy derived from the 230 million ha of Canada's managed forest using a dynamic systems approach. The authors took into account forest carbon stocks, C stored in harvested wood products including landfills, expected bioenergy use and facility types, and the likely alternative energy system displaced by the bioenergy to calculate how net GHG emissions vary over time and across the country. Two indicators of mitigation potential are presented: break-even points, the time required for bioenergy system emissions to be equal to those of the alternative energy system; and the cost effectiveness of using bioenergy to reduce GHG emissions. The authors concluded that (1) forest sector mitigation options need to be assessed rigorously from a systems perspective to avoid the development of policies that deliver no net benefits or substantially delayed benefits to the atmosphere, (2) alternative uses of the harvest residues need to be considered in the analysis, and (3) displaced emissions result in mitigation benefits that continue to accumulate, thereby increasing their importance over time.

Inclusion of carbon cycle and albedo in life cycle assessment for bioenergy. Soldal, E., Rørstad, P. (*Norwegian University of Life Sciences, Norway; ellen.soldal@nmbu.no; per.kristian.rorstad@umb.no*).

Bioenergy is promoted as part of the solution for climate change. Comprehensive and thorough methods are needed to evaluate the effect of climate change mitigation measures. Four different methods for accounting of biogenic CO_2 and two methods for inclusion of albedo were addressed in this paper. The methods were applied to two case studies in Norway: bioethanol used for heavy-duty transport and chips-fired district heating. Global warming potential (GWP) was used as a metric. A method was developed which includes carbon emissions and sequestration in the forest. In the boreal forest, which is snow-covered part of the year, albedo is an important climatic driver. As the forest is harvested and re-grown, the albedo changes. Both factors were included in this method and converted to the GWP metric, which can be used for life cycle assessment. Results show that the accounting of biogenic CO_2 is important. When addressing bioenergy from forests as slow growing as the boreal forest, the time horizon for analysis is particularly important. Over the short term (20 years), the albedo has an important cooling effect and the carbon has a warming effect. Over the longest time horizon (500 years) the GWP of the bioenergy (excluding fossil emissions tied to production) approaches zero.

Comparing methodologies for assessing forest ecosystem services in South Korea. Song, C., Lee, W., Choi, H., Moonil, K. (*Korea University, Republic of Korea; cholhosong@korea.ac.kr; leewk@korea.ac.kr*; *sosobut@korea.ac.kr*, *windy7up@naver.com*).

The ecosystem services that forests provide are indispensable for maintaining human activities. Many studies have attempted to evaluate ecosystem services in South Korean forests. However, the validity of early evaluation methodologies needs to be verified. For example, the most used indicator for valuing the water purification function of forests relies on precipitation, so the value of forests fluctuates yearly. To solve this problem, previously widely used methods should be functionally compared with other models that could potentially be adopted for South Korean forests. By comparing results, the authors will be able to suggest more accurate approaches for valuing forest ecosystem services. In addition, mapping ecosystem services is one of the key elements for improving decision-making and implementing ecosystem services, but it has not yet been done. Therefore, the results of the comparisons in this study will be described spatially. Using these comparisons and GIS, the applicability of models to South Korea at the national and local level can be analyzed. Furthermore, links are suggested between economic valuation and the quantification of results of ecosystem functions, and additional direction is provided based on the applicability of models.

Growth dynamics of silvertop ash regrowth forests in East Gippsland in response to contrasting thinning and fertiliser applications: A twenty-year evaluation. Soraya, E. (*Australian National University, Australia; emma.soraya@anu.edu.au*).

Various silvicultural treatments have been applied for more than two decades in East Gippsland, Australia, to increase silvertop ash's wood productivity and value by shortening sawlog rotation. However, reports published mainly short-term results. This study aimed to update the report of the growth dynamics of silvertop ash regrowth forests in East Gippsland in response to different thinning and fertiliser applications 20 yr after treatment. Data for this study came from experiments established by CSIRO and the Victorian Department of Sustainability and Environment. All stands are almost pure and were naturally regenerated following harvesting and burning. There were 13 treatment combinations between thinning and dosage of N and P fertilizer application. Results showed that 20 yr since treatment, mean basal area (BA) of individual trees in thinned plots was relatively bigger than that of the unthinned plots. However, because there were more trees in unthinned plots than in thinned plots, total BA/ha in unthinned plots was higher. Trees in thinned and fertilised plots showed increased BA/ha. About 13–20% of all retained stems in thinned plots were in the sawlog size class compared to only 4% in unthinned plots.

Carbon stock and dynamics of pioneer and non-pioneer forest species in an undisturbed forest in the Brazilian Amazon. Souza, C.R., Azevedo, C., Rossi, L.B. (*EMBRAPA, Brazil; cintia.souza@embrapa.br; celso.azevedo@embrapa.br; marcelo.rossi@embrapa.br*).

Great attention has been given to the effects of global climate change, and it is known that tropical forests play an important role in this issue. However, most research has considered the forest as a whole, with no distinction between the different ecological

groups and their influence on carbon dynamics. This study was conducted in an area of primary forest belonging to EMBRAPA Western Amazon, using data from three forest inventories conducted in 2005, 2007, and 2010, which measured all trees with DBH ≥10 cm. The aim of this study was to evaluate carbon dynamics in pioneer and non-pioneer forest species in an area of unmanaged forest, between 2005 and 2010, in order to determine the contribution of pioneer species (which have fast growth, and therefore absorb more carbon from the atmosphere) to the carbon balance of the area. Results showed that the pioneer species did not contribute significantly to the volume or to the carbon stock in the forest studied; only 13% of the local carbon stock was related to the pioneer species.

Contribution of Sapotaceae, Burseraceae, and Lecythidaceae families to carbon sequestration in an unmanaged forest in the Brazilian Amazon. Souza, C.R., Azevedo, C., Rossi, L.B. (*EMBRAPA, Brazil; cintia.souza@embrapa.br; celso.azevedo@embrapa.br; marcelo.rossi@embrapa.br*).

Tropical forests play an important role in the issue of global climate change. This study was conducted in an area of primary forest belonging to EMBRAPA Western Amazon, in Manaus/Amazonas. In this area, most species (approximately 40%) belong to the Lecythidaceae, Sapotaceae, and Burseraceae families. Data were used from three forest inventories that measured all trees with DBH ≥10 cm in 2005, 2007, and 2010. Considering the large representation of individuals of these families in the study area, the goal of this project was to evaluate the contribution of species in these three families to the carbon balance of the area between 2005 and 2010. The results showed that 31.3% of the timber volume of forest species studied was related to the selected families. The same can be observed in the case of carbon stock: 32% of the total carbon stock of the unmanaged area came from the three families studied. This contribution is significant but was expected, given that these families account for a large proportion of the forest species on the site.

Contribution of forest management to carbon sequestration in the Brazilian Amazon. Souza, C.R., Azevedo, C., Rossi, L.B. (*EMBRAPA, Brazil; cintia.souza@embrapa.br; celso.azevedo@embrapa.br; marcelo.rossi@embrapa.br*), Santos, J., Higuchi, N. (*National Institute of Amazonian Research (INPA), Brazil; joca@inpa.gov.br; niro@inpa.gov.br*).

The Amazon forest has received increased attention as global discussions consider the role of forests in global climate change. Burning or thinning forests can increase greenhouse gas emissions. On the other hand, carbon can be absorbed from the atmosphere through the growth of the stand. This study analyzed data from three forest inventories to evaluate the contribution of forest management to carbon sequestration, by quantifying carbon stocks and dynamics in a Central Amazon forest. No difference was found between logging treatments after 23 years of application. The control treatment (without logging) showed the highest carbon stocks. The carbon stocks in the forest equaled the existing stocks in 1986, prior to the experimental logging, indicating total recovery of the forest in terms of biomass. Nevertheless, the area may not be ready for harvest again, mainly due to the high number of pioneer species still existing in the managed area. In other words, the forest has recovered in terms of biomass but not in terms of species composition.

Modeling bark thickness and volume for Norway spruce (*Picea abies* [L.] Karst) in southwest Germany. Stängle, S., Brüchert, F, Nakou, A., Sauter, U. (*Forest Research Institute Baden-Wuerttemberg, Germany; stefan.staengle@forst.bwl.de; franka.bruechert@forst.bwl.de; Aikaterini.Nakou@Forst.bwl.de; udo.sauter@forst.bwl.de*).

Precise bark thickness estimates are important to calculate log diameters inside bark from measurements outside bark and to assess the availability of bark biomass. National forest inventories usually are based on diameter measurements outside bark, so wood volume can only be calculated with precise bark thickness estimates that should reflect regional conditions. In Central Europe the wood volume that is relevant for trade agreements between forest owner and wood buyer, can be calculated with modeled inside bark diameters using outside bark measurements. Another use for bark models is in bucking optimisation software for harvesters. Bark has become a valuable fuel, and bark components can be extracted for high-value biomaterial production. Thus, the assessment of available bark biomass is important to estimate the potential of such technologies for generating additional income for the forestry sector. Existing bark models have shown that bark thickness is strongly influenced by site conditions. Changing climate and increased nitrogen deposition, as well as changing silvicultural practices, might therefore have influenced relative bark thickness in the study area. This paper presents the results of modeling bark thickness for Norway spruce based on easy-to-measure tree variables, such as stem height, as well as seasonal changes, regional variation, and genetics.

Perspectives on integrating multi-phenological and multi-sensory remote sensing data into operational forest management. Stoffels, J., Hill, J., Mader, S., Sachtleber, T. (*Trier University, Germany; Stoffels@uni-trier.de; hillj@uni-trier.de; mader@uni-trier.de; sachtl@uni-trier.de*), Langshausen, J. (*Rhineland-Palatinate State Forest Administration, Germany; Joachim.Langshausen@wald-rlp.de*).

In the Federal State of Rhineland-Palatinate (Germany), local forest management plans are currently based on databases comprising attributes of various forest stand characteristics. Due to the prohibitive costs of traditional inventory concepts, there is a strong interest in exploring remote sensing as a replacement or complementary strategy. Emphasis is placed on detailed forest cover maps that, beyond their direct information content, can be used as stratification layers for reducing or optimizing field sampling efforts. Remote sensing-based forest inventory methods have to meet high quality requirements because of the high variation in forest communities and forest structure and the fragmentation of the Central European forested area. The aim of this study was to classify the main tree species and development stages of the total forest area in Rhineland-Palatinate (>800 000 ha) using multi-temporal ASTER, SPOT-5, and RapidEye data. To overcome current limitations in achieving acceptable mapping results within topographically heterogeneous and structurally complex forest systems, a spatially adaptive classification approach has been developed. The quality of the derived maps complies with the requirements of the state forest service. Further work will be focused on complete integration into forest management operations. Additionally, a conceptual framework will be presented for using Sentinel-2 data to support an optimized integrated inventory design.

Relationships between ground cover biomass and prescribed fire in longleaf pine forests in the southeastern United States. Stokes, T., Samuelson, L. (*Auburn University, USA; stoketa@auburn.edu; samuelj@auburn.edu*), Gonzalez-Benecke, C., Martin, T. (*University of Florida, USA; cgonzab@ufl.edu, tamartin@ufl.edu*).

Longleaf pine (*Pinus palustris* Mill.) ecosystems in the southeastern United States have high levels of plant diversity. Prescribed fire is important for longleaf pine ecosystem management, but we have a limited understanding of relationships between ground cover biomass and time since a burn. The objective of this research was to quantify relationships between ground cover biomass and time since prescribed fire in longleaf pine forests varying in age and forest structure and located throughout the range. Ground cover (all plants <1 m in height) biomass was examined in 19 longleaf pine stands ranging in age from 5 to 90 years in Georgia and Louisiana. Significant relationships between ground cover biomass and basal area and time since burn were observed and are discussed. Results from this study provide data needed to model the dynamics of forest growth after prescribed fire and to parameterize a carbon cycle model being developed for longleaf pine carbon management.

New approach for extracting growth trends and climate information from radial increment of Scots pine and Norway spruce. Suty, N. (*Swedish University of Agricultural Sciences, Sweden; nicole.suty@slu.se*), Grudd, H. (*Stockholm University, Sweden; hakan.grudd@natgeo.su.se*).

Climate-corrected estimates of forest growth are part of the official annual statistics produced by the National Forest Inventory in Sweden. Tree-ring indices are used as a proxy for climatic factors. A new approach can be based on statistical methods that are commonly used in the field of dendroclimatology and contribute to a better understanding of the effect of climate on volume growth estimates in forestry applications. Climatologists use tree rings to reconstruct climate patterns that go further back than on-the-ground temperature and precipitation records. Foresters use the same ring widths to calculate biomass and carbon budgets within a much shorter time frame. In this study the methods for producing tree-ring indices developed by Swedish foresters were evaluated and methods like regional curve standardization and the signal-free detrending concept were tested on the same data. There is potential for improving the measurements. For example, short series produce a biased chronology that fails to preserve recent climatic trends. Inventory data are collected annually over large areas and allow for studies of complex growth responses and spatial diversity. Regional climate-growth relationships become increasingly interesting in a global context, and large climate networks and tree-ring databases can benefit from forestry data.

Historical investigation of forest landscapes and their various uses in the early 20th century, based on national forest management plans. Suzuki, A., Matsuura, T. (*Forestry and Forest Products Research Institute, Japan; asakom@ffpri.affrc.go.jp; matsuu50@ffpri.affrc.go.jp*), Sano, M. (*Forestry Agency, Japan; masakoto@affrc.go.jp*)

Various natural and socio-economic forest-related data has been periodically recorded for nearly one century in Japan, in the form of national forest management plans (NFMPs) and their ancillary forest-type maps. These are precious data for investigating forest landscape history, particularly in the early 20th century, when aerial photographs and satellite imagery were unavailable. The present study examined the use of these historical national forest data to estimate past forest landscapes and their uses in a protected forest in the Tadami district of western Fukushima, Japan, where these data were fully available. There, we found rich information on forest types, forest age, logging methods, and their local uses, some of which had not been recorded in current NFMPs. In addition, we were also able to clarify the locations of past anthropogenic disturbances of timber and charcoal production for harvesting various edible wild plants and household woodwork industry by local inhabitants. Such information could be particularly useful to investigate the historical background of forest landscapes in detail, which could be the basis for conserving various ecosystem services related to cultural/biological diversity.

Risk analysis and forest scenario modeling. Tewari, V. (*Institute of Wood Science and Technology, India; vptewari@yahoo.com*).

Due to the long-term planning horizons and the great variety of natural, economic, and operational hazards affecting forest ecosystems, uncertainty and multiple risk are typical aspects of forest management. Applications of risk analysis are surprisingly rare, in spite of the rich assortment of sophisticated forest planning tools that are available today. Forest scenario models evaluate multiple management options and answer "what if" questions about a particular development path of a given forest. Forest scenario planning may reduce uncertainty in management outcomes by anticipating the future in a systematic way, thus reducing the likelihood of unexpected events. It can also improve the chance that future developments will agree with specified objectives. Numerous techniques are available for generating and evaluating scenarios of forest development. Some of them are limited to applications in simple forest production systems; others are suitable for any type of forest management. Risk analysis, risk evaluation, and risk management are formal procedures for quantifying, evaluating, and managing risk within a given hazard domain. Applications of risk analysis in forest scenario planning are scanty and greater emphasis needs to be placed on hazard prediction. This article discusses some aspects of risk analysis.

Comparing spatially and non-spatially explicit algorithms to implement thinnings in an individual tree growth model for cork oak stands. Tomé, M. (*Technical University of Lisbon, Portugal; magatome@isa.utl.pt*), Amaral Paulo, J., Soares, P. (*Technical University of Lisbon, Portugal; joanaap@isa.utl.pt; paulasoares@isa.utl.pt*).

Incorporation of thinning into individual tree models requires: (1) the selection of an index/variable to represent thinning intensity or residual stand density (such as removed or residual basal area or relative spacing), here designated by thinning index; and (2) implementation of some rule to select the trees to be thinned (thinning algorithm). Two thinning algorithms are compared for cork oak stands. The first is a spatially explicit algorithm based on the Hegyi competition index. The tree with the highest competition index value is the first thinned. After a tree is thinned, the competition indices of the trees in the neighbourhood of the thinned tree are re-computed and the tree with the highest competition index value is again selected to be thinned. This process is repeated until the intended value of the thinning index is achieved. The second is a non-spatially explicit algorithm based on a model that estimates the probability of a tree to be thinned. A thinning probability is estimated for each tree, the trees are randomly sorted, and the decision as to whether to thin each tree is taken by comparing its thinning probability with a random number (Monte-Carlo simulation). Trees are sequentially thinned until the intended thinning index is achieved.

Genomics-assisted selection of white spruce benefits from SilviScanTM: advanced phenotyping technology for measuring industrially relevant wood traits. Tong, T. (*FPInnovations, Canada; Tessie.Tong@FPInnovations.ca*), Beaulieu, J. (*Natural Resources Canada; jean.beaulieu@NRCan.gc.ca*), Sherson, G. (*FPInnovations, Canada; gail.sherson@fpinnovations.ca*).

With the rapid advancement in genotyping technologies, genotyping is becoming more affordable and will no longer be a limiting factor in forest genetics research. To keep pace with these developments, there is an increasing need for precise, high-throughput, and cost-effective phenotyping for wood and fibre traits in genomics research. Advanced phenotyping technologies such as SilviScan can facilitate the acquisition of wood traits accurately and efficiently for large sample sets. SilviScan rapidly and cost-effectively determines multiple wood traits on the same increment core or wood disc sample. It offers high resolution pith-to-bark measurements of fibre diameter, wood density, microfibril angle, modulus of elasticity, cell wall thickness, ring width and area, fibre coarseness, and cell population. The data have applications in many fields, such as resource characterization, forest inventory enhancement, forest management decision-making, forest genetics research, tree improvement, and adaptation to climate change. This poster illustrates the benefits of SilviScan in forest genetics research and describes a pilot study to test for association between single nucleotide polymorphisms (SNPs) of candidate genes and wood traits in white spruce. Genomic selection in boreal conifers appears particularly promising for traits that must be assessed at a more mature stage, such as wood quality traits.

Green public areas as an increase to the connectivity between forest remnants in urban landscapes. Toppa, R.H., Correia, S.G., Moraes, M.P. (*Federal University of São Carlos, Brazil; toppa@ufscar.br; silvania.goularte@gmail.com;na_moraesrp@hotmail.com*).

The average distance between the Brazilian Atlantic Forest fragments is 1 440 m, making it essential to ensure that these remnants are not isolated in the landscape. This study investigated if green public areas (GPA) improve the connectivity between patches of native vegetation and a Protected Area in the city of São Vicente, in the coastal zone of São Paulo state, Brazil. The connectivity index for 100 m and the nearest neighbor distance were used as landscape measurements to compare two scenarios in the city: one containing only natural vegetation fragments, and another, in which the regional GPA were included. The average Connectivity Index was found to be 42,010 between natural vegetation fragments and 42,028 in the scenario with the GPA. The average distance between the fragments was 41 m in the scenario with natural vegetation and 17 m in the scenario with the GPA, representing a 59% reduction in the average distance between the fragments. This reduction of the average distance between the natural vegetation remnants in the presence of GPA confirms that these areas can contribute to the connectivity of urban landscapes.

Evaluation of the revegetation process in forest fire areas for the monitoring and modeling of aerial biomass. Treviño Garza, E., González-Tagle, M., Aguirre Calderón, O., Jiménez Pérez, J. (*Universidad Autónoma de Nuevo León, Mexico; eduardo.trevinogr@uanl.edu.mx; Marco.gonzaleztg@uanl.edu.mx; oscar.aguirrecl@uanl.edu.mx; javier.jimenezp@uanl.mx*), Lopez-Ochoa, L. (*Mexico; lopezochoa.luis@gmail.com*).

This work consisted of a multi-temporal assessment of natural vegetation areas in the Sierra Madre Oriental in northeastern Mexico where wildfires occurred in 1998. Biomass was monitored using spectral values of five sets of satellite images acquired as follows: 1998 after the fire (Landsat), 2001 (Landsat), 2004 (SPOT), 2010 (SPOT), and 2012 (RapidEye), all of which were processed digitally. In addition, a stratified random sampling was performed in areas that did not have another fire after 1998. Analysis of vegetation recovery based on reflectance values indicated that after the fire only 9% of the area showed evidence of live vegetation but that 99% of the area did by 2012. Before the fire, imagery showed the area contained mixed forests of pine-oak, oak-pine, and oak. Analysis of field data showed the tree species that have been established in burned areas. With these values biomass volume present in the communities was calculated.

Forest information in Brazil: evolution and strengthening. Trindade, A., Pieruzzi, F. (*Brazilian Forest Service, Brazil; ana.trindade@florestal.gov.br; fernanda.pieruzzi@florestal.gov.br*).

Brazil is a country with vast forests, yet until the early 2000s information on forest resources was widely dispersed. Further, government agencies had little capacity to collect and organize information to meet national demand and respond to requests from the international forestry community. This paper describes the evolution of the organizational capacity of forest information in Brazil, as part of a strategy for creating and consolidating a national forest information system, driven by the need to respond to international questionnaires, such as the Global Forest Resources Assessment (2005, 2010, 2015) by the Food and Agriculture Organization of the United Nations, Joint Forest Sector Questionnaire (2005–2012) organized by the International Tropical Timber Organization (ITTO), and the Criteria and Indicators report of ITTO. Experience in production of these reports over the years highlights the continuing need for data collection and management, helps to identify important variables to assess the condition of forests and the forest sector, and points out the shortcomings of information. It also shows the need for cooperation between the Brazilian Forest Service, research and educational institutions, and governmental and non-governmental organizations, which should work together to establish national procedures, terms, and definitions.

Protected areas adaptation to future climate and land use changes in northern Thailand. Trisurat, Y. (*Kasetsart University, Thailand; fforyyt@ku.ac.th*), Kreft, H. (*University of Goettingen, Germany; hkreft@uni-goettingen.de*), Katzenstiner, K. (*University of Natural Resources and Life Sciences (BOKU), Austria; klaus.katzenteiner@boku.ac.at*).

The objectives of this research were to assess the impacts of future land use and climate change scenarios on the distributions of mammals in northern Thailand and to determine how much additional land should be protected to cope with the projected impacts. Occurrence data of 17 selected mammals were obtained from a nationwide inventory during 2004–2006. Current and predicted future bioclimatic variables in 2050 were extracted from global data sets. In addition, the maximum entropy model was used to generate suitable habitats. The results revealed that future climatic conditions would favor species living in habitats with dense forest cover. However, most species were predicted to lose suitable habitats if the remaining forest cover declines from the current level of 57% to 50% in 2050. When land use and climate changes were combined, the predicted impacts were more

severe. Most species would lose suitable habitats and the average shift in distribution was greater than 40%. Centers of mammal richness currently occur in large and contiguous protected forests, and were predicted to persist in the future although the percentage of moderate to very high concentrations would decrease marginally in the future. If 1 861 km^2 were added to the current protected areas, this minimal conservation effort (from 31.4% under the current plan to 32.5%) will significantly increase coping capacity.

Towards precise estimation of foliar biomass turnover rates in Finland. Tupek, B., Lehtonen, A., Heikkinen, J., Peltoniemi, M., Ukonmaanaho, L., Hokkanen, T., Nöjd, P., Nevalainen, S., Lingren, M., Mäkipää, R. (*Finnish Forest Research Institute (METLA), Finland; boris.tupek@metla.fi; aleksi.lehtonen@metla.fi; juha.heikkinen@metla.fi; mikko.peltoniemi@metla.fi; tatu.hokkanen@metla.fi; pekka.nojd@metla.fi; seppo.nevalainen@metla.fi; martti.lingren@metla.fi; raisa.makipaa@metla.fi*).

Precise litter input estimates are a prerequisite for studying environmental effects on soil carbon stock development. However, if the litter inputs are estimated using regionally averaged turnover rates, then the smaller-scale effects of significantly different litter inputs on soil carbon development may diminish. The authors tested the foliar turnover rates estimated from long-term measurements of the needle-cohort counts used in soil carbon models, such as in the Finnish greenhouse gas inventory, and turnover rate estimates from litterfall measurements. The counts of needle-cohorts were measured across Finland on an extensive network of 1 064 Scots pine and Norway spruce stands between 1995 and 2006. Litterfall measurements were conducted between 1960 and 2010 on 40 Scots pine, Norway spruce, and silver and downy birch stands. Litterfall-based estimates indicated larger litter input rates than those based on needle counts, which means that current turnover rates used in soil carbon models are underestimated. A better understanding of dynamic processes linked with nutrient reabsorption before shedding of foliage may be a key factor for further improvement of litter input estimates.

Biomass and forest carbon accounting in cold-temperate ecosystems in northern Mexico. Vargas-Larreta, B. (*Instituto Tecnológico de El Salto, Mexico; bvargas@itelsalto.edu.mx*), Castedo-Dorado, F. (*Universidad de León, Spain; fcasd@unileon.de*), Corral Rivas, J., López-Sánchez, C. (*Universidad Juárez del Estado de Durango, Mexico; jcorral@ujed.mx*, *calopez@ujed.mx*).

Forest management can contribute to carbon sources and sinks, and forest managers could benefit from having a scientific tool to evaluate the potential impacts of management activities on the C stocks and stock changes on their forests. Durango is the first forest reserve of Mexico, so it is important to quantify the potential of these forests to mitigate CO_2 emissions. The aim of this study was to quantify forest carbon storage and the carbon sequestration rate in Durango forests. A total of 1 346 trees were sampled across 201 permanent plots (50 m × 50 m) systematically established throughout the study area. Biomass equations for tree components (stem wood, bark, branches, and leaves) and total aboveground biomass for 24 pine and oak species were developed. Parameters of equations were obtained simultaneously to ensure additivity using the generalized method of moments approach (R^2 = 0.87–0.97, RMSE = 18.3–90.5 kg). Results showed that the average biomass in the study area (3 500 000 ha) was 81.25 Mg/ha. Total C stores amounted to 172 550 000 Mg, and the rate of C sequestration was 0.81 Mg/ha, or 2 822 560 Mg C/yr. Forest management emits 2 310 000 Mg CO_2/yr, plus 12 016 000 Mg CO_2/yr, due to deforestation (1.9%). Improvements in forest management practices are seen as an important way to increase the carbon sink strength of Durango forests.

Towards harmonized monitoring of water provisioning, regulating, and purifying services in urban forests. Vilhar, U., Verlič, A, Žlindra, D., Simončič, P., Japelj, A (*Slovenian Forestry Institute, Slovenia; ursa.vilhar@gozdis.si; andrej.verlic@gozdis.si; daniel.zlindra@gozdis.si; primoz.simoncic@gozdis.si; anze.japelj@gozdis.si*).

In recent years there has been increasing focus on ecosystem services provided by urban forests, such as supplying fresh water, purifying water, and regulating water runoff. Researchers have conducted extensive environmental monitoring and collected evaluation data, potentially informing forestry practice, decision-making, and policy. However, information about the extent to which urban forests fulfill their water-related ecosystem services remains limited. In order to better inform public and private entities about the capacity of urban forests to provide water, protect its quality, and regulate runoff, harmonized monitoring of selected core indicators in a network of European cities should be considered. The authors propose and test a set of core indicators for urban forests in the city of Ljubljana, Slovenia. Criteria for these indicators include being necessary, effective, easy to establish, and feasible.

Variation in floristic composition during secondary succession of forests in Cataniapo River Basin, Amazonas state, Venezuela. Villa, P., Infante, J. (*Instituto Nacional de Investigaciónes Agricolas (INIA), Venezuela; villautana@gmail.com; jdinfantet@gmail.com*), Montilla, M. (*Ministerio del Ambiente, Venezuela; mmontilla@gmail.com*), Delgado, L. (*Instituto Nacional de Investigaciónes Agricolas, Venezuela; ldmonsanto@gmail.com*).

The dynamics of secondary succession forests in Amazonas are highly variable and depend largely on the types of disturbances. The aim of this research was to evaluate changes in the floristic composition of secondary forests with regeneration at different successional stages. Plots of 20 m × 50 m were established with different ages of succession, and in primary forest. The relative abundance of species previously identified (DBH 2.5–10 cm, >10 cm) was measured. The evaluation was conducted in five successional stages (3–4 yr, 7–8 yr, 11–12 yr, 15–16 yr, 19–20 yr) and primary forest. As a general trend the floristic composition was highly variable between the early stages of succession, and among pioneer species in relation to later stages and primary forest. Differences were observed in relative abundance among species in each successional stage, and between successional stages. During the first stage, *Aegiphilla* intermediate successional species, *Cecropia sciadophylla, C. ficifolia,* and *Jacaranda copaia* were the dominant species. In advanced stages *Parkia pendula* spp. and *Unonopsis velutina* were the dominant species.

Species richness and forest productivity: a large-scale geospatial analysis. Watson, J., Liang, J. (*West Virginia University, USA; jamesvwatson6@gmail.com; alpenbering@gmail.com*), Tobin, P. (*U.S. Forest Service, USA; ptobin@fs.fed.us*).

Large-scale forest inventory data were used to determine the effects of tree species diversity on the productivity of forested ecosystems. U.S. Forest Inventory and Analysis (FIA) data were compiled from every U.S. state (except Hawaii) to study the relationship between the productivity of the >100,000 permanent sample plots and diversity of trees that are present on these plots. GIS layers of the current basal area, basal area from a previous inventory, site productivity, and the number of species present at a given location were developed. Based on these maps, the relationship between forest productivity and explanatory variables including tree species diversity, total stand basal area, elevation, and slope was analyzed. A positive association was found between tree species diversity and stand productivity consistently across most of the forest types in the United States. This study helps to answer whether an increase in biodiversity improves ecosystem services and what risks are posed by a declining biodiversity to humans and the environment.

Fake forests and quantifying uncertainty in allometric equations for the 'real world'. Wayson, C. (*SilvaCarbon, USA; cwayson.silvacarbon@gmail.com*), Carrillo Negrete, O., Olguín Alvarez, M. (*Proyecto Mexico-Noruega, Comisión Nacional Forestal, Mexico; oswaldisma@gmail.com; olguin.conafor@gmail.com*).

In calculating biomass from allometric equations there are choices of what published equation to use for a particular tree. Often, however, the uncertainty associated with this choice is not included in error estimates. In an effort to examine the impacts of choice of allometric equation on levels of uncertainty, the authors performed a thought experiment by creating a fake forest with characteristics similar to Mexican forests in terms of diameter distribution and a 'known' biomass with 100 000 individuals. An optimal sample size and distribution of diameters for an allometric equation were calculated. From here, the authors analyzed the effects of n, distribution of n, range of n, and equation form on the uncertainty estimates of biomass for the forest as a whole. This work tries to illuminate the effects of allometric equation choice on uncertainty for forest carbon estimates such as those of Mexico. A decision tree algorithm has been created to select the most appropriate equation from the equation database for Mexico, in an effort to reduce overall uncertainty in carbon estimates for Mexican forests.

Detection and quantification of forest carbon in intact tropical rain forests of Brunei Darussalam using remote sensing for REDD+. Yoon, M., Lee, W., Lee, J., Son, Y. (*Korea University, Republic of Korea; lovemihae@gmail.com, leewk@korea.ac.kr; jylee1559@hanmail.net*), *yson@korea.ac.kr*), Kamariah, A. (*University of Brunei Darussalam, Brunei; udhl_2003@yahoo.com*).

Quantification of tropical forest carbon is important for the REDD+ MRV system in climate change science and policy. However, accurately quantifying carbon in intact tropical rain forests has posed challenges because of the complex structure of these forests. This study aimed to estimate carbon storage in tropical rain forests with the next-generation remote sensing (hyperspectral image and synthetic aperture radar (SAR)) technology and to ENHANCE? elaborate remote sensing technology by field measurements for the REDD+ project. The 25-ha forest dynamics research plot in the Heart of Borneo at Kuala Belalong, Brunei, was selected for this study. Within this plot, six 20 m × 20 m sub-plots located along the altitudinal gradients were chosen. Leaf area index and DBH were measured on these sub-plots. The optimal regression equation based on field study, remote sensing data, and various spectral characteristics will be generated. A combination of physical information derived from SAR imagery and optical information derived from the hyperspectral image will be used to estimate carbon storage more accurately. Mapping of forest carbon storage in the extended area will be conducted through cross-validation between remote sensing data and field survey data. This study was carried out with the support of "Forest Science Technologies Development Project (Project Number: S121313L130120)" provided by the Korea Forest Service.

Influence of extreme storm events on forest soil carbon stock changes in Baden-Wuerttemberg, Germany. You, B. (*Albert-Ludwigs-University Freiburg, Germany; Bin.You@Forst.bwl.de*), Hanewinkel, M. (*Swiss Federal Institute for Forest, Snow and Landscape Research, Switzerland; marc.hanewinkel@wsl.ch*).

Forest ecosystems play a crucial role in the global carbon cycle, and forest soil carbon stock and fluxes account for a large part of the carbon budget in terrestrial ecosystems. However, the influence of extreme storms on soil carbon stock has not yet been well studied. In this study, a process-based soil carbon model was calibrated by means of Bayes's theorem to update the parameter values of the model (YassoBW) for the state of Baden-Wuerttemberg in Germany. During the process of Bayesian calibration, litter input from living biomass and mortality was estimated based on the National Forestry Inventory (NFI). The repeated measurements of SOC were derived from the soil surveys and then compared with the model outputs. The Markov-Chain-Monte-Carlo (MCMC) method with standard metropolis algorithm was used to explore the parameter space of the YassoBW model. Then it was applied to determine the impact of an extreme storm, Lothar, on the forest soil carbon stock changes in Baden-Wuerttemberg under different climate change scenarios because soil carbon decomposition rate depends greatly on temperature and soil moisture. Sensitivity analysis was implemented to reflect the magnitude of influence of climatic data on soil carbon prediction. Various post-storm management strategies were also integrated to demonstrate their effects on soil carbon stock accumulation in the long-run.

A geostatistical approach to integrate the national forest inventories and monitoring issues within the scope of REDD+. Zamora Lopez, S.Z., Koehl, M. (*University of Hamburg, Germany; szamora.lopez@gmail.com*), *michael.koehl@uni-hamburg.de*), Ramírez, C. (*Food and Agriculture Organization, Peru; carla.ramirez@fao.org*).

The purpose of this research was to evaluate the applicability of geostatistical techniques to national forestry inventories at a national and sub-national scale. The authors used 371 clusters of samples collected in Nicaragua during 2007–2008 by the National Forest Inventory. Tree characteristics such as height, diameter, biomass, volume, and health, as well as soil texture and other variables were analyzed. Methods included exploratory spatial data analysis and geoprocessing such as areal interpolation and empirical Bayesian kriging. Geostatistical techniques show promise for downscaling or upscaling the data samples from forest inventories, and for predicting values and their standard errors. This study highlights the variables suitable for a geostatistical approach. This approach can be used for such purposes as identifying trends, predicting values of key variables, identifying gaps in specific areas, defining indicators of forest inventories, and facilitating cost-effective monitoring. Evidence is provided about how these geostatistical techniques can support decision-making on forest assessments at both a national and a sub-national

scale. In addition, this study stresses the need to use a geostatistical approach for better integration of the national forest inventories and monitoring issues within the context of REDD+.

Forest crown closure retrieval using an inverted geometric-optical model. Zeng, Y., Wu, B., Zhao, D., Zhao, Y. (*Chinese Academy of Sciences, China; yuanz@irsa.ac.cn; wubf@irsa.ac.cn*), *zhaodan@irsa.ac.cn; zhaoyj@irsa.ac.cn*).

The objective of this study was to use an inversion of the Li-Strahler geometric-optical model combined with a scaling-based endmember extraction method to retrieve a forest canopy structural property, crown closure, in the Three Gorges region of China. A space-borne Landsat-8 image covering the whole study area and airborne hyperspectral PHI3 data located in a typical forest nature reserve were acquired at the same time in 2013. First the viewed surface components endmembers were extracted from the Landsat-8 data by the regional scaling-based linear unmixing model using the corresponding PHI3 image. Then crown closure was derived and mapped by inverting the Li-Strahler model based on the extracted endmembers. Finally, the model results were validated using field measurements and regional crown closure estimated from airborne LiDAR data. It can be concluded that the physically based Li-Strahler geometric-optical model could be inverted for estimating forest canopy structure, and the scaling approach may solve the mixture problem, may better extract the input for model inversion, and also could expand forest mapping from a local to a regional scale.

Effects of forest recovery on runoff and river discharge at different scales in a subtropical area of China. Zhou, G. (*Chinese Academy of Sciences, China; gyzhou@scib.ac.cn*), Zhou, P. (*Guangdong Academy of Forestry, China; zhoupinger@sinogaf.cn*).

Information on how forest recovery affects water resources is important as concerns arise over possible shortfalls in water supplies. This study examines the effects of forest recovery on water resources at different scales. At a regional scale, water budget analysis and time-series analysis were used to determine the effects of significant forest recovery on river discharge during 50 years (1960–2009) for the entire Guangdong Province. Contributing variables such as precipitation, potential evapotranspiration, development of impervious areas, human water consumption, and reservoir construction were quantitatively examined. The amount of surface runoff after forest recovery was examined at a hill-slope scale. The results showed that at the slope scale, forest recovery significantly decreased surface runoff ($P < 0.001$). At a large scale, surface water supplies did not decrease significantly as the forest recovered over the last 50 years in this subtropical area ($P > 0.05$), and forest recovery played a positive role in increasing water yield in the dry season.

Estimates of forest biomass carbon storage in Liaoning province in northeastern China: a review and assessment. Zhou, L. (*Chinese Academy of Sciences, China; zhouli930@163.com*).

Accurate estimates of forest carbon storage and stock change is critical for analyzing the effects of forest management on the capacity of forest carbon sinks. Using data from China's Continuous Forest Inventory, this study compared estimates of forest biomass carbon (FBC) storage in Liaoning province derived from different methods. Substantial variation occurred in estimates of FBC storage for young and middle-aged forests. For forests in Liaoning province with high proportions of trees in the young and middle age-classes, the continuous biomass expansion factor (CBM) method by forest type with age class was found to be more accurate for estimating forest biomass. Based on this method, forests in Liaoning province are a carbon sink, and increased from 63.03 Tg C in 1980 to 120.87 Tg C in 2010, with an annual increase of 1.93 Tg C. The average carbon density of forest biomass in the province increased from 26.15 Mg/ha in 1980 to 31.02 Mg/ha in 2010. The largest FBC occurred in middle-aged forests, but the average carbon density decreased in these forests between 1980 and 2010. The increase in forest carbon density resulted mainly from the increased area and carbon storage of mature forests.

Methods for determining the thresholds of forest gaps (treefall gaps) Zhu, J., Zhang, G. (*Chinese Academy of Sciences, China; jiaojunzhu@iae.ac.cn; zgq04713@163.com*), Wang, G. (*Clemson University, USA; gwang@clemson.edu*), Li, X. (*Shenyang Agricultural University, China; lixiufen2009@163.com*), Yan, Q. (*Chinese Academy of Sciences, China; qlyan@iae.ac.cn*).

Forest gaps created by treefall are considered to play an important role in forest ecology because they are the major driving force in maintaining the forest cycle. However, there are inconsistencies in how the upper and lower limits of gaps (from 4 m^2 to 4 ha) are defined. These inconsistencies make it difficult to compare gap research. The authors suggested that the upper limit of the gap be estimated by calculating the mean value of the shade silhouette length (SSL) of the canopy trees surrounding the gap (CTSG) during the growing season, which can reflect the maximum range of impact of CTSG in the gap. The gap lower limit is obtained by estimating the mean value of the minimum SSL of the canopy depth (at 12:00 local time) during the growing season, which can reflect the minimum range of impact of CTSG in the gap. The gap thresholds vary depending on both the location and the height or canopy length of CTSG. The ratio of gap diameter (GD) to canopy height (CH) was used to indicate gap thresholds. For example, at 41°08′53″N, 121°12′6″E, the upper limit of the gap is GD:CH = 3.02 and the lower limit of the gap is GD:CH = 0.29. The authors recommend that the gap size be uniformly determined using the method proposed in this study.

GENERAL POSTER SESSIONS

IUFRO Division 5: Forest Products

Radial variation of wood density and wood anatomy of *Quercus* spp. (Fagaceae) in Japan. Abe, H., Kuroda, K., Yamashita, K., Yazaki, K., Noshiro, S., Fujiwara, T. (*Forestry and Forest Products Research Institute (FFPRI), Japan; abeq@affrc.go.jp; kurodak@affrc.go.jp; zaikana@affrc.go.jp; kyazaki@ffpri.affrc.go.jp; noshiro@affrc.go.jp; fujiwara@ffpri.affrc.go.jp*).

We analyzed the radial variation of the basic density of 35 wood samples from14 species of *Quercus* in the Xylarium of FFPRI which were collected from all over Japan. In addition, in order to investigate the difference in the anatomical features of the inner and outer parts, transverse sections were observed by optical microscopy, and the vessel areas of both parts were measured. In most of the samples of the ring-porous wood, basic densities showed highest values near the pith, becoming lower toward the outer part. For the radial-porous wood, two kinds of patterns were mainly observed in the radial variation of basic densities. One was a slight increase outward from the pith which then decreased, and another was almost constant within a sample. These changing patterns from the inner to the outer in the radial-porous wood could be explained with the changes in vessel area. The average values of the difference between maximum and minimum densities within a radial series of a sample were 0.082 g/cm^3 in ring-porous wood (deciduous species), and 0.041 g/cm^3 in radial-porous wood (evergreen species). In tree species used in this study, *Q. phillyraeoides* had the highest density.

Sustainable utilization and marketing of selected non-timber forest products to support the handicraft industry and the development of rural communities. Aggangan, R., Natividad, R., Tamolang, F., Ella, A., Cortiguerra, E. (*Forest Products Research and Development Institute, Philippines; rtaggangan@gmail.com; ranfprdi@yahoo.com; mt2data@yahoo.com; arsie_ella@yahoo.com; emscortiguerra@yahoo.com.ph*).

This project was conducted to support and promote the sustainable utilization of selected non-timber forest products (NTFPs) to strengthen the production and export capabilities of the handicraft industry and the development of rural communities in Quezon and Camarines Norte, Philippines. Non-timber forest products inventory was done in each project site to generate data on the available NTFPs species, volume, density, and growth of regenerants for the PO information and reference relative to the harvesting, propagation, and plantation development of preferred NTFPs. Moreover, implementation of various capability building activities significantly enhanced the knowledge and skills of the POs on NTFP harvesting, processing, and utilization technologies. The organized handicraft producers' group in the project sites had started selling handicraft products in the local market. Strategies to enhance their product promotion and marketing included installation of product display areas, participation in provincial, regional, and national trade fairs, and preparation of product brochures. Linkages were established with government support agencies to provide further assistance on product development and marketing. The handicraft producers' group in each province was federated to improve production and marketing capability to deliver in case there was a high quantity of orders from exporters or local handicraft traders.

Comparing the potential of black pine essence for use in pharmaceutical industries: case study of Ardebil and Guilan provinces, North Iran. Akbarzadeh, M., Kouhgardi, E., Mikaeili, H. (*Islamic Azad University Iran; mehrdad.ak@gmail.com; kouhgardi@yahoo.com; mikaelih@yahoo.com*).

The goal of this study was to introduce the most important effective material of black pine, and also to introduce the best zone in view of percentage of essence constituents. Sampling was conducted in Ardebil and Guilan Provinces in the north of Iran. In each sampling, a total of 30 trees were selected in three repetitions with 10 trees per repetition. Three leaves were sampled from each tree. The leaves were dried in the shade and their essence was then extracted through a water distillation method by using Clevenger system. After that, the composition of the effective materials of the essence was identified by gas-burning chromatography system connected to the mass spectrophotometer. The results of variance analysis showed that there was a significant difference in the studied zones in view of percentage of evaluated composition. Based on the results, 147 compounds were identified in Ardebil which is 86.61% of total components of the essence. In addition, 137 compounds were identified in Guilan which is 85.96% of total components of the essence. It can be generally concluded that the most important identified components include alfa-pinene, bicycloheptane, camphene, beta-pinene, beta-flandern, alfa-tripinolen, bicycle-heptane, trans caryophyllene, germacrene, delta cadinene, alfa-humulene, and beta-mayerson that have high pharmaceutical values.

Analysis of defects in wood flooring manufactured by Brazilian companie members of a certification quality program. Andrade, A., Milan, M., Takeshita, S., Jankowsky, I. (*University of São Paulo-ESALQ, Brazil; arielandrade@usp.br; macmilan@usp.br; takeshita.sa@gmail.com; jankowsky@usp.br*).

Wood floorings are considered products of higher added value, and the occurrence of defects, especially in the final product, is not desirable as they may cause installation problems that can generate customer dissatisfaction. In Brazil, the National Hardwood Flooring Association (ANPM) has developed a certification program to improve the quality of products. In this sense, this research aimed to analyze the defects of wood flooring that occur in manufacturers. The methodology involved conducting audits in various companies. In total, 120 audits were carried out with companies in the ANPM program and 4 audits were with nonmembers. Audit procedures and classification of defects obeyed Brazilian standards. The results showed that defects considered non-conformities represented 6.1% of analyzed pieces in the wood flooring of the companies participating in the program. For companies that were not members of the program, 28.4% of analyzed pieces presented non-conformities. For companies participating in the program, the most common defects were surface checks, gaps, and pieces with twist. Companies not participating in the program had more failures in the procedures related to the processing, handling, and classification of wood flooring than companies members of the program.

Evolution of quality wood flooring in Brazilian companies members of a certification program. Andrade, A., Milan, M., Takeshita, S., Jankowsky, I. (*University of São Paulo-ESALQ, Brazil; arielandrade@usp.br; macmilan@usp.br; takeshita.sa@gmail.com; jankowsky@usp.br*).

In Brazil there are few initiatives related to quality certifications for wood products. One of the existent quality certifications involves wood flooring and was developed by the National Hardwood Flooring Association (ANPM). However, it is not known if this certification actually generated positive impacts on product quality. In this sense, the goal of this research was to present and analyze the evolution of the quality of wood flooring in Brazilian companies that participate in the program of quality certification developed by ANPM. The methodology involved the collection and analysis of information obtained from six companies and eight complete audit cycles. The results showed that, in general, carrying out the audits increased the quality standard of wood flooring. It was also possible to conclude that the item defects, thickness, and width have better consistency in quality standards, being easier to control, and the item moisture has the worst constancy in quality standard and is more difficult to control.

Combined compression and thermal modification of silver birch and European aspen sawn wood: color changes along the profile. Antikainen, J., Mottonen, V., Heräjärvi, H. (*Finnish Forest Research Institute, Finland; jukka.antikainen@metla.fi; veikko.mottonen@metla.fi; henrik.herajarvi@metla.fi*).

Compression drying combined with thermal modification is a potential method for improving the utilization rate of light-weighted wood species. The density profile through thickness is modified with compression and the thermal modification is used to reduce the set-recovery of the product. Despite the strong discoloration of wood by thermal treatment, a uniform color along the wood profile is desired. Therefore, this study will examine color changes of silver birch (*Betula pendula*) and European aspen (*Populus tremula*) along the sawn wood profile processed with different combinations of degree of compression and temperature. The color changes were measured by 3 mm steps from the surface layer to the core of specimens using a spectrophotometer. Measured spectral information was transformed to the CIELAB color space in order to evaluate the differences between the layers. The results showed that the average color difference (deltaE) along the profile with birch was between 3.81 and 5.49. With aspen the color differences were even lower from 2.44 to 4.47. To conclude, the combined compression and thermal modification do not dramatically affect the color changes along the profile. Therefore, it is a potential method for improving the utilization rate of light-weighted wood species.

Strategies for sustainable dependence on the forest: the case of wood carvers in Ghana. Appiah-Kubi, E. (*Forestry Research Institute of Ghana, Ghana; appiahkemma@yahoo.com*), Agyeman, K. (*Kwame Nkrumah University of Science and Technology, Ghana; kkagyeman.cass@knust.edu.gh*).

The essence of the forest in the socio-cultural and economic life of the people of Ghana cannot be overemphasized. However, there is tremendous imbalance between the forest and its dependents. This is because there is no correspondence between population growth and increase of the forest cover. People who constitute clusters of carvers and the market have increased at the expense of the forest. This is evident in the distances carvers cover these days to attain the rapidly-depleting wood species required for their works. This is coupled with increasing difficulty in meeting the demands of large markets. The causative factors to this situation were investigated both qualitatively and quantitatively through review of salient documents and interviews of stake holders. The data was analyzed cognitively and statistically to paint the real picture of the situation. This situation is related to the forest management strategies, leading to proposed sustainable dependency strategies under the two categories of benefits Ghanaian carvers derive from the forest. These are captured under direct and indirect dependence strategies targeted at curtailing the rapid depletion of the forest notwithstanding sustainable livelihood for the Ghanaian carver.

Promotion and utilization of plantation grown timber species in Ghana: the kiln drying schedule of *Khaya ivorensis*. Appiah-Kubi, E., Opuni Frimpong, E., Essien, C., Tekpetey, S. (*Forestry Research Institute of Ghana, Ghana; appiahkemma@yahoo.com; eopunifr@mtu.edu; caessien@ymail.com; nii9lartey@gmail.com*), Kankam, C. (*Kwame Nkrumah University of Science and Technology, Ghana; ckkankam@hotmail.com*), Mensah, M. (*Forestry Research Institute of Ghana, Ghana; mmensah@csir-forig.org.gh*).

Khaya ivorensis (Mahogany) is ranked as one of the best known and most valuable commercial tropical timbers on the international market. It is acknowledged that these species are becoming scarcer in the wake of dwindling forest cover in Ghana, with illegal logging as the major contributing factor. Since plantation species have not been used much in the past, their kiln schedules had also not been developed, and their drying rates and sensitivity to stain, surface checks, collapse, honeycomb, and warp are unknown. In this study, a kiln drying schedule for plantation grown *Khaya ivorensis* was developed. Results indicated that the mildest drying conditions (that is the lowest initial temperature, smallest initial wet bulb depression, and the lowest final temperature) for the plantation species would be 65 °C and 90 °C for the initial and final temperatures, respectively, and this coincided with the temperature schedule T11. The wet bulb depression (WBD) of 5.5 °C also corresponded with WBD schedule of 5. So for the plantation species, in putting together the mean adopted classes of initial moisture content of B, the WBD class of 5 and the temperature schedule of T11, Madison Drying Schedule T11-B5 is proposed.

Exploring lesser used timber species in Ghana for greener construction: a case of *Cola gigantea* and *Ficus sur*. Appiah-Kubi, E., Wilson Owusu, F. (*Forestry Research Institute of Ghana, Ghana; appiahkemma@yahoo.com; fwowusu3@yahoo.com*).

The sustainable use of lesser-used-species (LUS) has been identified as important for green construction and the sustainable management of forests. In this study, the mechanical properties of two LUS species were determined for efficient utilization in the construction industry. Properties that were determined include static bending strength (MOR), modulus of elasticity (MOE), compressive strength, and hardness and shearing strength. Five trees of *Cola gigantea* and four trees of *Ficus sur* were extracted from two ecological zones in Ghana for the study. The logs were converted to 25 mm and 55 mm thick boards and air dried to about 12% moisture content. The tests were carried out using an Instron universal testing machine. Results revealed that *Cola gigantea* had a mean modulus of rupture (MOR) of 77.5 N/mm^2 with a mean density of 493 kg/m^3 whilst *Ficus sur* had a mean

MOR of 50.85 N/mm^2 with a mean density of 376 kg/m^3. The mean MOE were 9 616 N/mm^2 and 5 707 N/mm^2 for *Cola gigantea* and *Ficus sur,* respectively. Based on the results, both species are generally good for end uses where strength and hardness are not critical requirements.

Profitability analysis of commercial processing of *Vitellaria paradoxa* on livelihood of rural dwellers in savanna area of Oyo State. Arabomen, O., Ayomide, A., Azeez, F., Odediran, F. (*Forestry Research Institute Of Nigeria, Nigeria; arabomenkevwe2009@yahoo.com; adedunmolalala@yahoo.com; abdfataiaranni2002@yahoo.com; festusbukola@yahoo.com*).

The objective of this study was to identify the socio-economic characteristics of processors of *Vitellaria paradoxa* and to examine the different benefits (profitability) that accrue to commercial processing of *V. paradoxa* in the study area. Three local government areas were selected for the study, and random sampling methods were adopted for the selection of respondents. Primary and secondary data were obtained through the use of questionnaires and relevant literature. Data collected were analyzed using descriptive statistical tools, presented in the form of frequency tables, percentages, and charts which were described accordingly. Gross margin analysis and rate of return on investment (RORI) were used to determine the profitability of processing of *V. paradoxa.* The results showed that 90% of *Vitellaria paradoxa* processors were female and 77.1% were within the age range of 21–40 years. They also indicated their primary occupation as farming, with the number of years of experience in processing of *V. paradoxa* (90%) as over 12 years. *V. paradoxa* processors (84.37%) indicated that income was the main economic benefit derived from this business with the RORI as 96% which indicated that the business is highly profitable since the higher the RORI, the higher the profitability.

Promotion and characterization of the mechanical properties of the non-timber forest product *Borassus aethiopum*. Asafu-Adjaye, O., Frimpong-Mensah, K., Darkwa, N. (*Kwame Nkrumah University of Science and Technology, Ghana; asibos@yahoo.com; frimpongmensahk@yahoo.com; nicdarkwa@yahoo.com*).

This study identifies two types of *Borassus aethiopum* (male and female) contrary to Dransfield's findings and discriminates their mechanical properties based on the tree's morphology. Literature on *Borassus aethiopum* tends to be limited to botany. The male is cylindrical and flowers but bears no fruits, while the female bears fruits and has a stem that is comparatively bigger in the middle and tappers towards both ends. Wood samples were collected from the three distinct zones: dermal, sub-dermal, and the central zones at 30%, 60%, and 90% of the trees merchantable height. Mechanical test specimens were prepared and tested in accordance with the British Standard BS 373:1957. The mean strength values at 12% moisture content (MC) at each interval of the male and female *Borassus* were significantly different at ($p < 0.001$) with the male recording the highest strength values. Mechanical properties significantly increased radially from the central zone to the dermal zone and axially decreased from the butt at 30% interval to the 90% interval. The mechanical properties of the dermal and sub-dermal zones can be used in applications requiring higher mechanical strength, whereas the central zone, owing to its low strength values, is not suitable for any application requiring direct load bearing.

Importance of *Pseudocedrela kotschyi* and *Mitragyna inermis* in well being of communities in Sudanian zone of Benin. Assede, E. (*Collaborator through University of Abomey-Calavi, Benin; assedeemeline@gmail.com*), Adomou, A., Sinsin, B. (*University of Abomey-Calavi, Benin; adomouaristide@yahoo.fr*), *bsinsin@gmail.com*).

The main reason for a growing interest in forest species is their increasing contribution to local livelihood. This study aims at assessing the uses and factors affecting the use of two forest species: *Pseudocedrela kotschyi* and *Mitragyna inermis*. Eighty individual interviews were held in the typical Sudanian zones of Benin. Four different tribes were involved: Berba, Waama, Gourma, and Fulani. This study combined quantitative and qualitative ethnobotanical approaches. Overall, 38 different uses were mentioned and 39.5% of uses were common to both species. The most important use is medicine. Even though all organs are used in the treatment of diseases, bark, leaves, and roots are the most important organs included in medicinal treatments. Bark, leaves, and root are respectively involved in 43.4%, 34.2%, and 42% of total uses. The importance of uses depends on species organ and varies between ethnic groups. In the case of *Mitragyna inermis*, Berba use more roots, the Gourma prefer the leaves, while the Fulani and Waama respectively use more bark and stem. All these collections are directly provided by natural forest stands. So, it will be useful to think about the domestication of these forest species.

Beekeeping as a source of livelihood strategy in Oyo State, Nigeria. Ayomide, A., Olugbire, O., Arabomen, O., Abi, E. (*Forestry Research Institute of Nigeria, Nigeria; adedunmolalala@yahoo.com; olugbireolutoyin@gmail.com; arabomenkevwe2009@yahoo.com; eneabi2008@yahoo.com*).

Beekeeping, popularly known as apiculture, is the art and science of raising honey bees for economic benefit. It refers to the practice and management of the bees in the hives, which leads to the production of valuable materials such as honey, beeswax, propolis, bee pollen, bee venom, and royal jelly. This study examined beekeeping as a source of livelihood strategy in Oyo State. The study was carried out in eight local government areas of Oyo State. A structured questionnaire and oral interviews were used to collect information relating to beekeeping housing systems, management techniques, production, marketing, and problems encountered in the business from 70 beekeepers. The result revealed that the majority of the respondents were male (86.11%) while the remaining (13.89%) were female. About 85% of the respondents reported that the purpose for rearing bees was to generate income. The major problem encountered by the beekeepers included lack of financial assistance, bee stings, and disease/insect outbreaks. Since beekeeping was the major income-generating business among the respondents, it was therefore recommended that the government should assist the beekeeper through provision of microfinance credit, processing equipment and encouragement of youth in the art of beekeeping.

Potential of the forest to produce raw material for the wood carving industry in Ghana. Baffo, B. (*Volta River Authority, Ghana; baffoblankson@gmail.com*).

The wood carvers' perceptions on the potential of the forest to produce raw material for the wood carving industry were studied at Enyirisi and Aburi in the eastern part of Ghana. Fifty workshops were selected in both communities using a systematic

sampling method to participate in the survey and two respondents were selected from each workshop. It was realized that out of over 126 different tree species that grow to the size capable of being used for all wood working purposes in Ghana, only 18 species were traditionally preferred for carving. Out of 18 that were being used, 72% were preferred by the carvers based on different perceptions. The majority (75%) of them had to travel distances between 80 km and beyond to get their wood supply, and most of them were (57.5%) from the farmlands. Other sources of supplies include forest (30%) and plantations (18%). The preferred species are now declining at an alarming rate with little or no attempt at replacing them. Recommendations were made to the government to involve all the stakeholders to address the problems associated with wood deficit on the carving industry.

Nanocellulose market volume projections: a derived demand analysis. Bilek, E. (*U.S. Forest Service, USA; tbilek@fs.fed.us*), Shatkin, J. (*Vireo Advisors, USA; jashatkin@gmail.com*), Cowie, J. (*Cowie & Company LLC, USA; john@cowiecompany.com*), Wegner, T. (*U.S. Forest Service, USA; twegner@fs.fed.us*).

Nanotechnology has enormous promise to bring about fundamental changes and significant benefits to society and to the forest products industry. This study created a methodology to estimate the potential volume of nanocellulose that will be used in diverse products and markets in the United States. Published data sources were used to identify research that cites the utility of nanocellulose for particular applications. Eleven potentially high-volume applications were identified along with 12 low-volume applications. In addition, three identified novel applications were considered to be potentially promising, but were not developed enough to make nanocellulose market demand projections. Volume projections were made by estimating nanocellulose market penetrations into representative end-product markets. Middle market-penetration estimates were bracketed by both high and low estimates to establish a plausible volume range for nanocellulose demand. When summed, the annual market potential in high-volume applications in the United States was approximately 12 million tonnes of nanocellulose, with nearly half coming from the combined packaging and paper industries. This estimate was based on current markets and our middle market-penetration estimates. The spread around this middle point is quite wide, ranging from around 45% less to around 55% more, reflecting the early stage of the technology development.

Timber trade and its effectiveness in the context of Slovakia. Brodrechtova, Y., Halaj, D. (*Technical University in Zvolen, Slovakia; brodrechtova@tuzvo.sk); halaj@tuzvo.sk*).

The aim of the study was to identify trade structures and analyze their effectiveness in achieving the economic goals of forest products companies. Coming from new institutional economics, an explanation of decisions for timber trade structures (institutional arrangements) and their influencing factors (transactional characteristics) based on agency and transaction costs was sought. A case study approach with a qualitative methodology was proposed due to the exploratory character of the study. Semi-structured in-person interviews were conducted with 19 experts, 11 forest enterprises, and 9 wood and 5 forest biomass processing companies in Slovakia selected via random stratified sampling. Transcribed interviews were subsequently examined with content analysis. The preliminary results indicate that private forest owners preferred spot market transactions over the short- or long-term contracts favored by state forest owners. The former were influenced mainly by uncertainty, whereas opportunistic behavior and transaction atmosphere also factored in the decisions of the latter. The timber processing companies primarily sought (long-term) contracts with state forest owners. Overall, effective achievement of economic goals for forest products companies was affected primarily by asset specificity and transaction atmosphere as competition for timber resources has considerably increased in Europe in general and Slovakia specifically.

Small enterprises and the U.S. secondary wood industry. Buehlmann, U. (*Virginia Polytechnica Institute and State University, USA; buehlmann@gmail.com*), Espinoza, O. (*University of Minnesota, USA; oaespino@umn.edu*), Bumgardner, M. (*U.S. Forest Service, USA; mbumgardner@fs.fed.us*), Sperber, M. (*LIgnum, United States; michael.h.sperber@gmail.com*).

The past decades have seen numerous large U.S. secondary woodworking companies shift their production to overseas locations, mainly in Southeast Asia. Also, companies in this important manufacturing sector have been hit hard by the downturn in housing markets and the following recession. Thus, many large customers of the U.S. hardwood lumber industry have reduced or stopped their purchases, leaving mostly smaller firms as the drivers of demand for the U.S. hardwood industry. It has become, therefore, important to understand the needs of these small firms in the current business environment. This study used a census mail survey to ask participants in six states (WI, OH, WV, VA, NC, and TN) questions to help determine the unique characteristics of small firms. Both, large and small firms attributed much of their success to their manufacturing capabilities and leadership prowess. Small firms used less formal paths to gather information and planned investments less formally. Small firms, in general, also purchased more hardwood lumber using distributors, and they requested fewer specialized services from their lumber suppliers.

Relationships between environmental impacts and added value in Norwegian wood processing industries. Bysheim, K., Tellnes, L., Nyrud, A. (*Norwegian Institute of Wood Technology, Norway; kristian.bysheim@treteknisk.no; lars.tellnes@treteknisk.no; anders.nyrud@treteknisk.no*).

An ecometric approach was used to assess environmental impacts and economic value in the Norwegian wood processing industries. The industries are classified according to international business categories (NACE). Microdata were used to calculate the accumulated added value and environmental burden for the different wood-based industries and the distribution of economic value and environmental impact within the supply chain. Normalized parameters for environmental performance serve as performance indicators for sustainable development in the supply chain. The results from this study can be used to identify areas in the wood-based supply chain to be targeted for environmental improvement and increased sustainability.

Effect of water availability on the radial profile of wood density by x-ray densitometry for *Eucalyptus grandis* at 36 months old in Brazil. Castro, V., Surdi, P. (*University of São Paulo-ESALQ, Brazil; vresende@gmail.com; paulasurdi@usp.br*), Laclau, J. (*CIRAD, France; laclau@cirad.fr*), Tommasiello Filho, M. (*University of São Paulo-ESALQ, Brazil; mtomazel@usp.br*), Chaix, G. (*CIRAD, France; gilles.chaix@cirad.fr*).

The x-ray densitometry is a classic methodology to analyze tree rings and obtain the radial wood density profile as well as the intra- and inter-annual tree-rings density variation. The wood densitometric profile can be applied to studies related to wood

quality of trees, genetic studies, and management practices. In this study, the x-ray equipment LX-60 (Faxitron) was used in the wood samples diametric in 48 trees of *Eucalyptus grandis* at two water regimes (100% of rain and 66% of rain). The hydric regime with exclusion of rain (66% of rain) was performed with artificial exclusion transparent polyethylene plies covering 34% of the soil surface. The results showed: i) the densitometric profile from pith to bark; ii) limit detection of cambial age at the first and second growth ring, and (iii) there is statistical difference for the density profile by Tukey statistical test between the two treatments of water regime. These results highlight the importance and effectiveness of the method used here as a methodology for nondestructive characterization of wood according to water drought effects.

Comparative wood anatomy of *Cordia trichotoma* (Boraginaceae) from seeds of two provenances and analysis of its growth rings. Caum, C., Marcati, C. (*São Paulo State University, Brazil; carol_caum@hotmail.com; crmarcati@gmail.com*), Longui, E. (*Instituto Florestal-São Paolo, Brazil; edulongui@gmail.com*).

Our goal was to correlate growth rings with temperature and rainfall and to compare the wood anatomy of *Cordia trichotoma* that grew up in the same environment at Luiz Antônio Experimental Station, Luiz Antônio, São Paulo, Brazil; however trees were derived from seeds collected from two natural populations of Bauru and Piracicaba in São Paulo State. We used stem discs collected at 1.30 m of six trees of each provenance. Standard techniques for wood anatomy were used. For growth rings, the discs were polished manually with sandpaper and the ring widths were measured using Image-Pro Plus. To check the data quality and accuracy, the cross-dating measurements were checked with COFECHA. ARSTAN program was used to compute the tree-ring chronologies. The relationship between growth rings and climatic factors was analyzed by Pearson's correlation. Significant differences were found in vessel grouping, vessel diameter, fiber diameter, fiber lumen diameter, and axial parenchyma/mm^2 suggesting that Bauru provenances are more restrictive to water conduction. For growth rings there was significant positive correlation between ring widths and temperature from August to October, months in which temperature is milder. A negative and significant correlation between ring widths and rainfall was obtained in April, the month in which rainfall decreases sharply.

Role of extractives in the photo-discoloration of *Cryptomeria japonica* wood caused by UV irradiation. Chang, T., Chang, S. (*National Taiwan University, China-Taipei; d00625001@ntu.edu.tw; peter@ntu.edu.tw*).

The role of wood extracts in the discoloration is an interesting topic when extractive-rich wood is exposed to UV light. Even though heartwood extract of *Cryptomeria japonica* (CJ) can promote the photostability of wood, the photo-discoloration of wood caused by UV irradiation remains unclear and needs to be elucidated. The aim of this study was to investigate the photo-discoloration of CJ heartwood. After 12-h short term irradiation, the red tone of CJ extract (CJE) from heartwood faded and the yellow tone increased. However, both tones of CJE eventually faded after 48-h long-term irradiation. The discoloration of non-extracted CJ heartwood (NCJW) was similar to that of CJE in the short-term irradiation period. But in the long-term irradiation period, NCJW's yellow tone increased continuously. Even though photo-yellowing occurred in NCJW, the degree of yellowing was less in NCJW than that of extracted CJ heartwood. These results indicated that the CJE could protect wood from photo-yellowing. Consequently, the total color difference of NCJW was limited. In conclusion, CJE not only protects wood from photodegradation but also inhibits its photo-discoloration.

Assessment for half-life and carbon stock of harvested wood products in Korea. Chang, Y., Park, J. (*Seoul National University, Republic of Korea; jang646@snu.ac.kr); gentleice@nate.com*), Son, W., Park, J., Park, M. (*Korea Forest Research Institute, Republic of Korea; tistructure@forest.go.kr; jusang@forest.go.kr; mjpark@forest.go.kr*), Yeo, H. (*Seoul National University, Republic of Korea; hyeo@snu.ac.kr*).

In the overall effort to reduce greenhouse gas emissions, people have much interest in the carbon storage role of harvested wood products (HWP) in the global carbon cycle. Carbon has been stored in HWP, such as wooden buildings and furniture, for a long period of time until the wood is burned or decomposed. In order to account for the carbon amounts in HWP, it is necessary to determine the lifespan of the HWP. The time that carbon can be stored in wood products can be expressed as the half-life, which is the time required for half of the carbon in a wood product to be transformed or eliminated by normal use. In this study, methods from other countries and conditions for determining the half-life of HWP were investigated. With statistics related to the carbon flow and the type of carbon stocks in domestic HWP, the half-life (time) of HWP in Korea was estimated. The results of this study show that HWP is an important type of carbon storage that should be considered in decisions associated with climate change adaptation and mitigation in Korea.

The current status of wood utilization for residential housing in Okinawa Prefecture, Japan. Chinen, Y., Shiba, M. (*University of the Ryukyus, Japan; akamayaa@yahoo.co.jp); mshiba@agr.u-ryukyu.ac.jp*).

Okinawa Prefecture is a group of islands at the southwest end of Japan. Wood demand and supply of Okinawa Prefecture consists of local timber produced from northern parts of Okinawa's main island, domestic timber from the southern region of Kyushu, and imported timber from foreign countries. The total wood demand has recently decreased, domestic timber increases and imported timber decreases, while only 10% of the local timber production still remains. This study presents the current status of wood utilization for residential housing in Okinawa Prefecture as it significantly influences wood demand as a whole. There is a remarkable difference between wooden house rates in Okinawa Prefecture compared to the rest of Japan due to several historical reasons including the U.S. government occupation administration policy after World War II. In 2003, the rate of wood and reinforced concrete utilized for single family house construction was 5% and 75%, respectively. However in 2012, production of new wooden housing had increased to 12%, and it is expected that the wood consumption and wood-related industrial activities will also increase in the near future.

Effect of heat treatment on the physical properties of moso bamboo (*Phyllostachys pubescens*). Cho, C., Lee, J. (*National Ilan University, China – Taipei; rockcho@seed.net.tw; clcho@niu.edu.tw*).

The objective of this study was to investigate the effects of heat treatments on the physical properties of moso bamboo (*Phyllostachys pubescens*). Heat treatments were performed at temperature levels of 170 °C, 190 °C, 210 °C, and 230 °C for time

durations of 1, 2, and 4 hours. The results indicated a value of 46.45% anti-shrinkage efficiency (ASE) in volume obtained with a heat treatment of 170 °C for 1 h, and a maximum value of 91.02% could be reached with the 230 °C treatment. These revealed that the heat treatment process could effectively improve the dimensional stability of moso bamboo. The color of bamboo turned dark and more uniform after heat treatment. The abrasion resistance of the bamboo treated below 210 °C was increased when compared to control samples. The compression strength parallel to grain of specimens heat treated below 190 °C were significantly higher than that of the controls, but were not obviously different when treated above 210 °C. The modulus of rupture and tensile strength parallel to grain decreased with an increase of the treated temperatures. The strength loss of MOR and tensile strength were 12.0 to 52.5% and 50.5 to 75.6%, respectively.

Microwave-assisted extraction of condensed tannins from maritime pine (Pinus pinaster) bark. Chupin, L., Reynaud, S., Charrier, B., Charrier, F. (*Université de Pau et des Pays de l'Adour (IPREM), France; lucie.chupin@univ-pau.fr; stephanie.reynaud@univ-pau.fr; bertrand.charrier@univ-pau.fr; fatima.charrier@univ-pau.fr*).

Microwave-assisted extraction was developed to obtain condensed tannin from maritime pine (*Pinus pinaster*) bark suitable for making wood adhesives. The bark was grounded and separated into four ranges of granular size. Extractions with ethanol/water (80/20) were performed on grounded bark of 400 to 100 μm at 100 W for 3 and 5 min and performed once, twice, or four times. For each extraction, the extraction yield was measured and analyzed by reverse phase high pressure liquid chromatography (RP-HPLC). A study of the effect of granular size on the extraction of condensed tannin was conducted on samples from a single 3 min extraction. The total soluble polyphenols (Folin-Ciocalteu) and condensed tannins (vanillin and BuOH-HCl tests) were quantified. The extracts were also characterized by RP-HPLC, Fourrier transformed infrared (FTIR), and thermogravimetric analysis (TGA). The smaller the size of the particles of bark, the more polyphenols and condensed tannins were extracted. The main components extracted were catechin, epicatechin, epicatechin gallate, and gallic acid. The TGA showed that the extracts start their thermal degradation at approximately 180 °C.

Financial analysis of charcoal production methods in Ghana. Darko Obiri, B., Marfo, E. (*Forestry Research Institute of Ghana, Ghana; bdobiri@yahoo.com; emarfo@csir-forig.org.gh*), Nunoo, I. (*Kwame Nkrumah University of Science and Technology, Ghana; nunooisaac85@yahoo.com*), Obeng, E. (*Forestry Research Institute of Ghana, Ghana; amadanso@yahoo.co.uk*).

The efficiency of charcoal burning methods has generally been studied, but knowledge on their economics is limited in Ghana. This paper assessed the profitability of the earth mound and brick and metal kilns for burning charcoal in Ghana to aid in investment decisions on the choice of the most viable technology. Input-output data was collected from 200 charcoal producers and subjected to financial cost-benefit analysis. Results indicated that charcoal production is profitable but less profitable with the earth mound due to wood and higher labor costs. NPVs at 22% for the earth mound, brick, and metal kilns were US $1200, US $2900 and US $7000, respectively. The metal kiln is movable, has the highest turnover, and is known for the best conversion efficiency. The earth mound has less cost in construction, but brick and metal kilns require substantial initial investment capital. The earth mound is criticized as being destructive to the environment, and producers reported drudgery and various health hazards associated with its use. Producers reported a high demand for charcoal, but a declining demand for wood resources. The need for sustainable wood sources and the most efficient and economic charcoal burning method is imperative. Producers require loans at lower interest rates to encourage the use of the metal kiln.

Yield and chemical composition of essential oils from leaves of two Brazilian savannah trees. Del Menezzi, C., Silva, A., Resck, I. (*University of Brasília, Brazil; cmenezzi@unb.br; aninha.kakau@gmail.com; isresck@unb.br*).

Essential oils are non-wood forest products widely used by pharmaceutical, food, and cosmetic industries. The Brazilian Savannah (Cerrado) is the second largest Brazilian biome, and it presents high biodiversity. There is a lack of information regarding yield and chemical composition of essential oils of plants from this biome. In this context, the main goal of this paper was to evaluate the yield and chemical composition of essential oils from two native trees: *Tapirira guianensis* (Aubl) and *Eugenia dysenterica* (DC). Leaves from both trees were harvested between September and October 2011. The essential oil from the material was extracted by steam distillation for 90 minutes using laboratory distillatory equipment. The fresh distillate was collected and the essential oil was separated from the hydrosol by using a solvent. The essential oil yields were 0.5% and 1.6% for *T. guianensis* and *E. dysenterica*, respectively. The main chemical components found were: 2-hexenal, 4-terpeniol, linalool, and geraniol. The last two are relatively important from the industrial point of view. Finally, it could be concluded that both species present the potential for extracting essential oils, and research efforts to study further Brazilian Savannah trees must be continued.

Drying dimension lumber: winning the game without breaking the rules. Erickson, R. (*University of Minnesota, USA; erick117@umn.edu*).

In manufacturing dimension lumber, 70% of the energy used during tree harvesting through final surfacing is for kiln drying. The wood's low permeability perpendicular to the grain is largely responsible. Permeability parallel to the grain is about 15 times as great. Unfortunately, end-grain only exists at board ends. The situation is like a clogged freeway. Taking advantage of rapid parallel movement requires periodic end-grain exits. This was done for green nominal 2 by 4s via saw cuts perpendicular to grain on both wide faces. An uncut shoulder remained along each edge, thereby creating a simulated I-joist. Drying time to a uniform 10% moisture content was nearly halved. Edgewise bending strength, per the I-joist principle, was essentially retained. Grading rules for nominal 2 inch thick dimension lumber allow a specific sized hole, or equivalent smaller ones, per board length. Current focus is on a forest-like distribution of micro holes that honors the rules. A needle-type roller incisor downstream of the head rig is a possibility. Benefits to drying and preservative treatments, obtained at low cost, appear attractive. A huge savings of energy plus dependable dimensional stability for huge amounts of structural framing lumber are worthy goals.

Bringing the forest in: establishing the link between the use of wood and health in the built indoor environment. Fell, D. (*Fpinnovations, Canada; David.fell@fpinnovations.ca*).

This study looked at autonomic nervous system responses to wood in the built indoor environment to promote health and well-being. Prohealth autonomic responses to forests and natural outdoor environments have been established in the literature for some

time. Evidence suggests that exposure to forests lowers sympathetic reactivity which, in turn, can lower blood pressure, heart rate, and promote healing. Unfortunately, in western cultures we spend very little time outdoors and even less in forests. For example, Canadians spend as little as 6% of their adult lives outdoors. This study set out to establish if there are similar autonomic responses to wood in the indoor environments we spend the majority of our lives in. A total of 119 subjects were assigned to either wood or non-wood offices. Galvanic skin response and interbeat interval were monitored continually through a baseline, stress-induced, and recovery period. Skin conductance responses were significantly lower in the wood room than in the non-wood room in all periods of the study. This provides evidence that natural wood elements in the indoor environment reduces sympathetic nervous system reactivity. This and other emerging research results are building the case for the application of wood in the pursuit of healthier indoor environments.

Impact of alternative fertilization with sodium on growth and wood quality of *Eucalyptus grandis* plantations in Brazil. Franco, M.P. (*University of São Paulo-ESALQ, Brazil; marianapfranco@usp.br*), Laclau, J. (*CIRAD, France; laclau@cirad.fr*), Sette Junior, C. (*Federal University of Goias, Brazil; crsettejr@hotmail.com*), Filho, M.T. (*University of São Paulo-ESALQ, Brazil; mtomazel@usp.br*), Chaix, G. (*CIRAD, France; gilles.chaix@cirad.fr*).

Climate changes result in hydrological cycle alterations, with impacts on distribution and quantity of rainfall affecting forest plantations in the tropics and subtropics. Trees minimize water stress effects by leaf osmotic adjustments which are dependent on K ions. *Eucalyptus* plantations were established in tropical and subtropical soils especially poor in K. Fertilization by substitution of K by Na is a potential alternative way, at lower cost and greater availability, that is especially suitable for smallholder plantations. For these reasons, we studied respective K and Na fertilization effects on growth and basic wood density of *Eucalyptus grandis* plantations with different objectives (domestic energy, timber). Significant differences in volume of trunk and wood density were observed on 8-year-old *E. grandis* trees fertilized with Na vs. K and the control. Trees with Na fertilization showed a significantly higher volume with Na vs. the control and a lower volume vs. K. Wood density and radial variability were significantly lower compared to trees with K and the control. In this paper we discuss the advantages of Na fertilization both to minimize the drought stress effect due to global climate change and to optimize economically the wood production of smallholder plantations.

Evaluation of sapote fruit (*Capparis scabrida* H.B.K.) characteristics in relation to tree size in a rural community in Lambayeque, Peru. Galindo Jara, F., Guzman Loayza, D., Gonzales Mora, H. (*Universidad Nacional Agraria La Molina, Peru; indira_galindo_jara@hotmail.com; deysigl@lamolina.edu.pe; egonzales@lamolina.edu.pe*).

Research was conducted in the rural community of San Julian Motupe, Lambayeque, Peru to evaluate the influence of tree structural characteristics (height and diameter) on the chemical properties of the fruits of *Capparis scabrida* H.B.K. (sapote). The study aimed to provide basic information that could be used to enhance the acceptance and value of this fruit. Fruits were collected from selected trees and total production per tree was calculated. Total fruit production averaged 19.1 kg/tree. Endosperm represented an average of 27% of the total weight of the fruit. The composition of these fruits averaged: 4.7% ash, 4.53% fat, 33.5% protein, 45.13% nitrogen-free extracts, and 11.71% crude fiber. Based on the analysis of the relationship between tree structural measurements and the fruit's physical and chemical characteristics, it was concluded that the amount of crude fiber endosperm in sapote fruit is influenced by the height of the tree.

The occurrence of wet pockets in the drying of *Acacia mangium* using a conventional steam-heated kiln. Gan, K., Rabidin, Z. (*Forest Research Institute, Malaysia; ganks@frim.gov.my; zairulamin@frim.gov.my*).

Acacia mangium is increasing being planted in the forest plantation program in Malaysia. This species is known to grow well and fast without much problem. The wood was previously used for wood chips, wooden pallets, and composite products, but now is increasingly being used for solid wood products such as outdoor furniture and joinery products. The timber can be successfully dried using a radio-frequency vacuum dryer, but the energy cost is high. However, when the conventional steam-heated kiln is used, the timber is known to dry slowly and is prone to collapse and wet pockets. This paper discusses the development of a drying schedule using a conventional steam-heated kiln and the use of kiln treatments to alleviate the occurrence of wet pockets when drying *Acacia mangium*. A standard drying condition was adopted to quickly evaluate the various pretreatments such as hot water bath, air drying, and microwave pretreatments. The results indicated that a combination of air drying and microwave pretreatment tended to minimize the occurrence of wet pockets when using the drying schedule developed.

Role of U.S. homebuilders' psychographic orientation in their adoption and use of certified wood in residential construction projects. Ganguly, I., Eastin, I., Bowers, C. (*University of Washington, USA; indro@uw.edu; eastin@uw.edu; taitb@uw.edu*).

The residential construction industry is the largest market for FSC and SFI certified wood in the United States, although unreliable supply and high price provides little economic incentive for homebuilders to use certified wood. However, the increasing use of green building programs (GBPs), which incentivize the use of certified wood, represents an opportunity to expand the demand for certified wood in the United States. This study utilizes the structural equation modeling (SEM) approach to develop a comprehensive understanding of the role of the homebuilders' psychographic orientations in influencing their use of certified wood in residential construction projects. The paper also analyses the recursive causal relationship between the GBPs and certified wood usage in U.S. residential construction projects. The empirical estimation of the model was based on responses obtained from a national survey of 513 residential homebuilders and remodelers conducted during the 3rd and 4th quarter of 2011. The modeling results reveal that the builders' environmental orientation positively influences their awareness and use of GBPs and wood certification programs. The results also reveal that green building programs play a statistically significant role in awareness generation and use of certified wood in the U.S. residential construction industry.

Optimization of dilute acid hydrolysis of I-214 poplar clone wood grown in Turkey. Gurboy, K. (*Istanbul University, Turkey; gurboyb@istanbul.edu.tr*), Bayramoglu, M. (*Gebze Institue of Technology, Turkey; mbayramoglu@gyte.edu.tr*), Mertoglu Elmas, G. (*Istanbul University, Turkey; mertoglug@istanbul.edu.tr*), Korkut, I., Ovali, B. (*Gebze Institute of Technology, Turkey; ikorkut@gyte.edu.tr; bovali@gyte.edu.tr*), Özden, Ö., Koçer, S.

Beneficiation of renewable energy sources is the solution to the growing energy demand for sustainable development all over the world. Ethanol is the one of the most popular renewable energy sources produced through fermentation of sugars. Potential sources for low cost ethanol are lignocellulosic materials chosen by considering economical, geographic, and climatic conditions of the country. Fast growing native trees such as poplar are suitable in terms of energy forestry in Turkey. Dilute sulfuric acid pretreatment at high temperatures is a leading technology for the thermochemical pre-hydrolysis of wood. This study is focused on the experimental optimization of dilute acid hydrolysis applied to the I-214 poplar clone grown in Turkey. Constrained D-optimal plan was used to obtain regression models of three process responses, namely hexose, pentose, and total sugar yields, which were separately optimized for the detection of suitable ranges of process factors.

The conversion yield from wood to charcoal can be estimated by near infrared spectroscopy. Hein, P., Trugilho, P. (*Universidade Federal de Lavras, Brazil; paulo.hein@dcf.ufla.br; trugilho@dcf.ufla.br*), Andrade, C. (*Universidade Federal de Goiás, Brazil; cra.florestal@yahoo.com.br*).

The charcoal produced from wood originating from planted forests is an important source of energy used in metallurgical operations as a reducing agent, especially in Brazil, the largest producer of green steel. The evaluation of the yields obtained in the carbonization process is extremely important when biomass is intended for charcoal production. High gravimetric yield in the carbonization processes is desired for several aspects, for instance, for a better utilization of the blast furnace in terms of volume per unit of wood used to produce charcoal. The aim of this study was to investigate the applicability of near infrared spectroscopy for monitoring the fixed-carbon content of the charcoal. Partial least square (PLS) regressions were established for estimating the gravimetric yield (GY) of the charcoal by means of the NIR spectra recorded from ground charcoal. The predictive models were validated by cross-validations and independent test sets. PLS-R models developed from first derivative NIR spectra for estimating GY provided R^2p of 0.79 and root mean squared error of prediction of ~2.43%. The promising findings on laboratory scale and conditions indicate that this approach could be implemented in steel industries for inspecting the quality of their raw material in real situations, where new solutions are required for controlling the charcoal productivity with speed and precision.

Optimizing wood utilization in regard to GHG emissions and primary energy consumption on a regional level exemplified for south-east Germany. Höglmeier, K., Weber-Blaschke, G., Richter, K. (*Technical University of Munich, Germany; hoeglmeier@hfm.tum.de; weber-blaschke@hfm.tum.de; richter@hfm.tum.de*).

Low value wood assortments like forest residues, residues from wood industry, and post-consumer waste wood can partly substitute for each other in various applications as an energy source and resource for materials such as particleboard. Recently, the concept of cascading, the sequential use of a certain resource for different purposes, is increasingly often proclaimed as the optimal way of utilizing those resources in order to minimize environmental impacts and especially GHG emissions. Yet, no comprehensive assessments of the environmental impacts of cascading in comparison to other utilization pathways are available on the level of whole regions. We conducted lifecycle assessments for various utilization scenarios of the wood amounts available annually in south-east Germany, focusing on production of energy and wood panels. A special focus was placed on cascading utilization ways. The effects of product substitution will be assessed by including functional equivalent non-wood products in the scenarios. The results will provide scientifically based information for an optimized allocation of low value wood assortments in terms of GHG emissions and primary energy consumption for the study area. The effects of the concept of resource cascading on the environmental impacts of wood utilization are identified.

Consumer preferences for wood product information content in sustainability context. Holopainen, J., Toppinen, A., Rekola, M. (*University of Helsinki, Finland; jani.m.holopainen@helsinki.fi; anne.toppinen@helsinki.fi; mika.rekola@helsinki.fi*).

Despite recent emergence of bioeconomy in policy and industry level rhetoric, little is yet know about in-depth stakeholder views on what constitutes sustainability when doing everyday material choices. This study seeks to fill the gap by expanding our understanding on the dimensionality of sustainability in consumer preferences towards wooden products. Factors behind the consumer value from sustainability were derived from the literature on sustainable consumption and tested on a specific case of wood products through a developed survey instrument. Four key contextual determinants for consumer preferences for sustainable and responsible wood products were identified, where one of the identified dimensions, named Information, was characterized by a variety of information on social and responsibility issues such as legality, also including a requirement for more information about environmental effects of wood products on health. In order to better understand and manage the content of this key determinant for the consumers' purchase decisions, it was divided into different genres including information on: (a) origin, (b) environmental sustainability, and (c) social values. The consumer valuation of these different items was tested by applying it to a choice experiment in the Finnish wood product market context.

Firewood production of *Eucalyptus urophylla* in Brazilian Savanna area. Imana, J. (*University of Brasilia, Brazil; jose.imana@gmail.com*), Santana, O. (*Federal University of Pernambuco, Brazil; otaciliosantana@gmail.com*), Meira-Junior, M. (*University of Brasilia, Brazil; milton.serpa@gmail.com*).

Brazilian *Eucalyptus* wood of 8 to 10 years old is normally destined to the industrial production of cellulose, panels, firewood, and charcoal. The objective of this work was to evaluate the silvicultural, management, and economic aspects of a reforestation company which works now with cut cycles of only 3 years. The study was accomplished in a *Eucalyptus urophylla* plantation in the central region of the Brazilian savanna. The cut rotation of 3 years is based into the regional market demand. Dendrometrical data were collected in 11 plots of 1 000 m^2, with approximately 150 trees for plot. About 9.64% of the trees were dead. The data base was formed of 1 545 living trees with an average DBH of 12 cm and 11 m for the total height. The volume production oscillated around 113.12 m^3/ha. Every year the company cuts approximately 5 000 ha, corresponding to 565.6 m^3 of firewood. The market cost of each m^3 for firewood is now US$ 1.35, therefore a value of about US$ 763.56 per cycle for the company. *Eucalyptus urophylla* firewood is being well accepted for the firewood consumer.

Intra-annual phloem and xylem formation and primordial shoot development in Norway spruce saplings exposed to elevated CO_2 and temperature. Jyske, T. (*Finnish Forest Research Institute, Finland; tuula.jyske@metla.fi*), Schiestl-Aalto, P. (*University of Helsinki, Finland; piia.schiestl@helsinki.fi*), Sutinen, S., Linkosalo, T. (*Finnish Forest Research Institute, Finland; sirkka.sutinen@metla.fi; tapio.linkosalo@metla.fi*), Zhang, C. (*Forestry and Forest Products Research Institute, Japan; chunhua@affrc.go.jp*), Hayashi, N., Kuroda, K., Abe, H., Pulkkinen, P.

In boreal conditions, climate change is predicted to affect the timing of phenological processes of Norway spruce (*Picea abies* (L.) Karst.). The spring phenology of trees (e.g., bud development, cambial activity) is mainly determined by photoperiod and accumulation of temperature and may advance due to the elevation in temperatures. Increasing concentrations of atmospheric CO_2 can also affect the phenology. Recently, many studies on intra-annual cambial activity have focused on xylem formation. However, vascular cambium is a bifacial meristem in which the cellular divisions produce new xylem (inward) but also new phloem (outward) followed by cellular differentiation. Our current knowledge on phloem formation and differentiation is fragmentary. The control and interrelations between xylem and phloem formation and other phenological growth processes have also attained less attention. We analyzed the timing and coordination of phenological growth processes in grafted saplings of Norway spruce exposed to conditions representing current climate and conditions forecasted for year 2080 (elevated CO_2 and temperature). The following parameters were measured: (1) photosynthesis, (2) development of primordial shoots in buds, (3) cambial reactivation and xylem and phloem formation and differentiation, and (4) the seasonal variation in nonstructural carbohydrates in xylem and phloem.

Comparison of color, brightness, and chroma of natural dye-coated veneer. Kim, J. Suh, J. (*Korea Forest Research Institute, Republic of Korea; jikim99@forest.go.kr; jssuh@forest.go.kr*), Park, R. (*Natural Dye Research Institute, Republic of Korea; busanminsok@hanmail.net*), Park, S., Yoo, B. (*Korea Forest Research Institute, Republic of Korea; parksb@forest.go.kr; boyoofri@forest.go.kr*).

The use of dye-coated veneer EC (echo crack seal) and OSM (Osmo) considerably changed the color hue (Munsell color hue). In non-treated Korean pine veneer, EC showed yellowish red (9.4) and OSM showed yellow (0.4). In the case of Korean pine veneer dye-coated by *Phellodendron amurense*, EC and OSM showed 5.4 and 7.4 of BG group, respectively. In the case of non-treated radiata pine veneer, EC and OSM showed 0.1 and 2.7 of yellow group, respectively. In the control (no dye), EC and OSM as public yellow system respectively showed 1.7 and 1.8 in the Yellow poplar veneer. The brightness of dye-coated Korean pine veneer showed a lower value than that of non-treated veneer, whereas Korean pine veneer stained with *Phellodendron amurense* showed higher brightness and chroma values. In the case of Korean pine veneer, chroma value showed higher in the order of *Phellodendron amurense*, non-treatment, and sappan wood.

Enzymatic biodegradable characterization of wood decaying fungi. Kim, M., Ahn, H. (*Korea Forest Research Institute, Republic of Korea; mkkim@forest.go.kr; with-hoon@hotmail.com*).

The biodegradation of woody biomass by wood rot fungus is a complex reaction of a number of enzymes. In this study, we checked various growth conditions (pH and temperature) from the representative wood rot fungus to investigate the expression of lignocelluloses-degrading enzyme genes as part of the basic study of the mechanism for the bioconservation of woody components such as cellulose, hemi-cellulose, and lignin. We cultured two white rot fungi, *Phanerochaete chrysosporium* and *Trametes versicolor,* and one brown rot fungus, *Tyromyces palustris* for 7 days in different conditions. The temperatures were 25, 28, and 30 °C, and pH was 4, 4.5, 5, 5.5, and 6. The best culture conditions were pH 5.0 and 28 °C for all three species. In the case of the growth rates, *P. chrysosporium* occupied the plate in 3 days, but *T. versicolor* was slow to grow and took 7 days. The gene expression of the lignocelluloses-degrading enzymes, cellulase, manganese-peroxidase, laccase, and lignin-peroxidase will be analyzed using RT-PCR and compared with each other as we further our study.

Heterologous expression of lignin-degrading enzymes from white rot fungi in *Pichia pastoris*. Kim, M., Ryu, S. (*Korea Forest Research Institute, Republic of Korea; mkkim@forest.go.kr; shryu@forest.go.kr*).

White rot fungi produce three types of lignin-degrading enzymes namely: laccase, manganese dependent peroxidase (MnP), and lignin peroxidase (LiP). Efficient and quicker strategies are required to transform these organisms using appropriate vectors in order to improve their efficacy for lignin degradation. To enhance the productivity of ligninolytic enzymes as well as obtain a simple, quick, and an efficient source of lignin-degrading enzymes from white rot fungi, the *laccase1* (pPICαLac1) and *MnP4* genes (pPICαMnp4) from *Polyporus brumalis*, *laccase* gene (pPICαPILac) from *Phlebia tremellosa,* and *MnP* gene (pPICαTVMnp) from *Trametes versicolor* have been cloned into vectors and successfully expressed in the *Pichia pastoris*, under the control of the methanol induced alcohol oxidase promoter (aox1). Laccase and MnP activities were measured using *o*-tolidine, ABTS, and DMP in *P. pastoris*. The activities of the transformants were observed to be significantly higher than that of the wild type. Heterologous expression of ligninolytic-enzyme-encoding genes from white rot fungi was successfully achieved in the methylotrophic yeast *P. pastoris* with efficient enzymatic activities of lignin-degrading enzymes.

Screening of fruiting genes in *Lentinula edodes*. Kim, M., Ryu, S, Bak, W. (*Korea Forest Research Institute, Republic of Korea; mkkim@forest.go.kr; shryu@forest.go.kr; wcbak@forest.go.kr*).

To obtain gene data related to *Lentinula edodes* fruiting, we used expressed sequence tags (ESTs) and differentially expressed gene (DEG) analysis. We screened several genes that were effectively expressed at different stages in the life cycle of *L. edodes* (inoculation, incubation, primordium formation, and fruiting) by microarray analysis. Next, we confirmed the expression of genes responsible for fruiting in *L. edodes* by real-time PCR. The effective genes identified were hexose carrier protein, β-galactosidase, and laccase 1 at the primordium stage and 1DEG11, cytochrome P450, 12-kDa heat shock protein (glucose and lipid-regulated protein), laccase 2′, and exo-β-1,3-glucanase at the fruiting stage. To our knowledge, 1DEG11 was identified as a gene underlying fruiting in *L. edodes*.

Sustainable management of copaiba (Copaifera spp.) for oil production: definition of an optimal rotation. Klauberg, C., Vidal, E., Rodriguez, L. (*University of São Paulo, Brazil; carine_klauberg@hotmail.com; edson.vidal@usp.br; lcer@usp.br*), Diaz Balteiro, L. (*Technical University of Madrid, Spain; luis.diaz.balteiro@upm.es*).

The study deals with the definition of optimal regimen cycles for copaiba trees (Copaifera spp.), a low-density species sparsely distributed in the Amazon Basin. The copaiba oil, a nonwood product extracted from adult trees, is an important source of income for local communities. The main objective of our study was to determine whether an optimal extraction cycle exists. This is part of a case study in the State of Pará (Brazil) where 118 different trees have been monitored since 2006. Data has been collected for different cycles between 1 and 5 years. Considering two different outcomes, oil production and net present value, we discuss the effect of introducing randomness during the process of determining the optimal cycle. Therefore, the question becomes: do we get the same result when the optimal cycle is determined by means of a deterministic analysis and a Monte-Carlo simulation analysis? According to the dataset used, the results consistently pointed to a 3 year cycle, regardless of the analysis method (deterministic and stochastic) and the way outcomes were measured (production or NPV). These results confirm previous recommendations published by other authors and predicted in the norms that regulate the management of copaiba trees in Brazil.

Harvesting the dead and decaying forests: potential carbon storage and avoided emissions. Klopp, W. (*University of Northern Bristish Columbia, Canada; wsklopp@gmail.com*).

The mountain pine beetle (MPB: *Dendroctonus ponderosae* H.) epidemic is among the most recent and largest natural disturbances to occur in British Columbia, Canada. The death and decay of these stands threatens sustainable forest management and their associated carbon (C) balances at both regional and provincial scales. Our project investigates potential C storage and avoided C emissions in harvesting these forested stands. Presented findings highlight the differences in net C balances of two differing wood products: softwood lumber and wood pellets. For our analysis a C accounting framework was created to track harvested wood products throughout their life stages using a reference flow of 1 m^3 harvested raw timber. This framework allowed us to differentiate points of emission and quality of the timber and enables comparisons between differing wood products and processes. Our findings demonstrate the critical role C neutrality plays in affecting the net C balance of the life cycle of either wood product.

Livelihood sustenance potentials of herbal medicine in rural areas of Abia State, Nigeria. Kola-Oladji, K. (*Forest Research Institute, Nigeria, Nigeria; kikdiji@yahoo.com*), Olutayo, L. (*University of Ibadan, Nigeria; lantopamtu@yahoo.com*).

This study was carried out to find the sustenance potentials of herbal medicine for the livelihood, survival, and sustenance of families in the rural areas of Abia State, Nigeria. A multi-stage stratified random sampling method was used for the study. A total of 207 household respondents were sampled with only one 185 valid for the study. Also, three sellers were randomly selected in each selected market, giving a sample size of 27 sellers of which 25 respondents were valid. Findings revealed that the market is heterogeneous in terms of sex and free in terms of entry. There is no restriction to age as all age ranges were involved. Affiliation to membership association is by choice unlike the trading at the household level. Transportation and other costs were very minimal resulting in a low total cost. A benefit-cost-ratio of 4.1 was obtained with a profitability ratio of 3.11, implying that for every dollar invested, there is a profit of $0.02 returns, showing that the business is very lucrative. A total of 61 families with 164 species were identified for sales/uses for the management and curing of different ailments. Respondents' were ready to adopt any improved technology introduced to conserve against eminent extinction.

Developing the evaluation method for wood stiffness of sugi (Japanese cedar, *Cryptomeria japonica* D. Don) at nursery stage. Kurahara, Y. (*Forestry and Forest Products Research Institute, Japan; yujikura@affrc.go.jp*).

Sugi or Japanese cedar (*Cryptomeria japonica* D.Don) is one of the most important tree species in Japanese forestry. As its lumber is more useful and it grows faster than any other major tree species in Japan, it has been planted in half of the country's 10 million hectare of managed forest. Wood stiffness, measured in term of its modulus of elasticity (MOE), is the most important property of construction lumber. Generally in pine species, specific gravity (SG) is usually a good indicator of wood stiffness. But Japanese cedar shows a weak relationship between MOE and SG. Therefore, MOE is regarded as a better indicator of the quality of Japanese cedar. There is a great variation in the MOE among individual cultivars in this species, and this variation is regarded as a disadvantage when wood of sugi is used in construction. But sugi has required long periods of time for wood stiffness breeding, and this long time (over 15 years) have hampered tree improvement. Therefore, a major aim of this exercise was to develop the method for evaluation of wood stiffness at the nursery stage by using the stress wave.

Morphological variability and nutrient composition of Tunisian aromatic Apiaceae *Magydaris pastinaceae* L. growing in the Northern Forest zones. Labidi Ben Slimane, A., Khaldi, A., Mohamed El Arbi, K. (*Institut National de Recherches en Génie Rural, Eaux et Forêts (INRGREF), Tunisia; arbia.labidi@hotmail.com; khalditn@yahoo.fr; khoujalarbi@yahoo.fr*), Ramona, T. (*AGQ Labs, Spain; rtorres@agq.com.es*).

Magydaris pastinaceae is an Apiaceae native to the Mediterranean basin. In Tunisia, the specie is present mainly in mogod forests (Northern region), and it is submitted to strong pressure caused by its harvest for use as incense aroma. It can be considered as endangered species. Scientifically, it can be considered as a neglected species because it is not well studied by scientists. The analysis of the morphological diversity and mineral composition of the species would help in its preservation, better valorized use, and potentially its culture. Morphological analyses of *M. pastinaceae* at 11 sites in Northern Tunisia (Beja, Bizerte, and Siliana) using 10 parameters inspired from the descriptors for Apiaceae (International Plant Genetic Resources Institute (IPGRI)) showed a significant difference between two parameters, plant length and fruit weight. Nutritional parameters (moisture, dry matter, crude fats, proteins, fibers, nitrogen, carbohydrates, and energy values) and nutrient analysis (K, Na, Ca, Fe, P, Mg, etc.) were evaluated in leaves, fruits, and roots of *M. pastinaceae* using standard techniques. The results showed that fruits of *M. pastinaceae* had the highest proportion of crude fats, fibers, and had the highest energy value. Leaves were also rich in essential minerals such as iron, calcium, magnesium, and potassium, while the trace elements and heavy metals composition were marginal.

Production of cellulose from wood: formation of oxidized groups and their effect on cellulose properties. Lachenal, D., Perrin, J. (*Grenoble INP-Pagora, France; dominique.lachenal@grenoble-inp.fr; jordan.perrin@grenoble-inp.fr*).

The interest of cellulose for purposes other than paper, such as textile and plastics, has been growing very fast during recent years. The main reason is linked to environmental considerations. Cellulose is a renewable polymer, available in considerable quantity. The problem is then to extract cellulose from wood and purify it using green processes. This was the topic of this work. More particularly, efficient green bleaching processes have been developed. They include the use of ozone. Characterization of cellulose after ozone treatment showed that it contained carbonyl groups. These new groups made cellulose very sensitive to alkaline conditions, which resulted in a marked darkening and a severe depolymerization in caustic soda solutions and also in a tendency to yellow under heat exposure. These drawbacks might be a serious handicap in the manufacture of textile fibers which requires strong alkaline treatments. It was found that carbonyl formation could be reduced by some modification of the ozone stage and that the carbonyl groups were almost entirely destroyed by a hydrogen peroxide treatment. The chemical mechanisms involved in these treatments have been explained. These results pave the way to the production of high quality cellulose by environmentally friendly processes.

Domestication of the prioritized medicinal and aromatic plants in community forestry. Lamichhane, D. (*Ministry of Forest and Soil Conservation, Nepal; dlamichhane@gmail.com*), Devkota, K. (*Institute of Forestry, Nepal; devkotakpd@yahoo.com*).

High value medicinal and aromatic plants (MAPs) play a significant role in biodiversity conservation and socioeconomic development in the mountainous areas of Nepal. The study was conducted in four community forests (CFs) of Kaski District to explore the nationally prioritized MAPs and assess their potential for cultivation, commercialization, and marketing, and to establish their demonstration plots. Two top prioritized MAPs from each of the four CFs were considered for analysis after conducting prioritization by local people. Methodology included the collection and analysis of socioeconomic and biophysical data using a semi-structured questionnaire, key informant interviews, plot establishment in the forest, seedling production, cultivation, and measurement of growth performance of selected MAPs. Research results revealed the significant variation in distribution of MAPs in the forest according to altitude, slope, aspect, and crown cover. Various growth performances of the selected MAPs were observed in cultivation under different treatments. Local people were found to have limited use of the valuable MAPs for occasional medicinal purposes. Forest users mostly lacked knowledge and information about collection, processing, and marketing of valuable MAPs. The existing high demand in national and international markets would indicate the enormous potentiality of valuable MAPs for economic development of rural communities.

Coumarins content of seed and crude oil of *Calopyllum inophyllum* from forest stands in Indonesia. Leksono, B. (*Center for Forest Biotechnology and Tree Improvement, Indonesia; boedyleksono@yahoo.com*).

Nyamplung (*Calophyllum inophyllum*) seeds, known as an alternative source of biofuel, have been revealed to contain coumarins compound, making it potentially promising as a medicinal source for disease therapy. Coumarins are components in seeds that need to be eliminated as a waste before the biofuel production process is conducted. This valuable source of coumarins as a drug has increased the value and function of nyamplung seeds. Coumarins are elements of phenylpropanoid compounds of which their derivates are pharmacologically essential for different physiological activities (anti-HIV, anti-cancer, anti-inflammation, anti-oxidant, anti-bacterial, anti-coagulant, analgesic, and comparative immune-modulation). The aim of this study was to examine variations of total coumarins content of nyamplung seeds from 12 nyamplung stands (6 Java island, 6 outside Java) throughout the seven islands in Indonesia. Results indicated a very high variation in coumarins content between nyamplung stands in Indonesia. The ranges of coumarins content in seeds from Java and outside Java were 0.101–0.354% and 0.261–0.412%, respectively. Variations were higher in crude oil, both fresh and one year preserved, in materials from the seven islands in Indonesia, with concentrations of 0.328–1.109% and 0.229–1.330%, respectively. Coumarins content and variations between stands have been shown to be higher in crude oil than in seeds.

Intra- and inter-island variations of biofuel content and their physical-chemical properties of *Calopyllum inophyllum* in Indonesia. Leksono, B., Hendrati, R., Windyarini, E., Hasnah, T. (*Center for Forest Biotechnology and Tree Improvement, Indonesia; boedyleksono@yahoo.com; rina.l.hendrati@gmal.com; e_windyarini@yahoo.com; triemaria@yahoo.com*).

A global energy crisis causing increasing biofuel prices has driven the world to emphasize the importance of environmentally-friendly renewable-energy (biofuel). *Calophyllum inophyllum* (nyamplung), whose seeds have long been used for biofuel, is one potential tree species with an energy source that can be harvested repeatedly for 50 years. Technical practices of biofuel production for nyamplung seeds have been developed at energy self-sufficient villages based on nyamplung in five villages in Java and one outside Java. Optimation of industrial production is hindered by the availability of research on biofuel content and quality. This research is carried out to reveal biofuel content variations of intra (six within Java) and inter (seven within Indonesia) islands and their properties, for genetically improving its seed sources. Results showed a great variation in biofuel content among populations. Values ranged between 37–48% vertical hot press (VHP) and 50–58% screw press expeller(SPE) for crude oil, 36–48% (VHP) and 40–53% (SPE) for refined oil, and 17–33% (SPE) for biodiesel. Highest variation in refined oil is due to high-content seed resin. All of the 18 properties tested varied, and most are in line with international standards of biodiesel. DNA analysis confirmed intermediate to high genetic variation, with two clusters for intra and inter islands. The results will be used to improve nyamplung breeding strategy.

Growth stresses and wood basic density of *Eucalyptus* related to the productivity of the plantation site. Lima, J., Silva, J., Trugilho, P. (*Federal University of Lavras, Brazil; jtlima@dcf.ufla.br; jreinaldo@dcf.ufla.br; trugilho@dcf.ufla.br*), Vieira, R. (*Federal University of Tocantins, Brazil; renato@vieiramail.com.br*), Cruz, C. (*Federal University of Reconcavo Of Bahia, Brazil; claircruz@ufrb.edu.br*).

One question that always preoccupies producers and wood researchers is the influence that the environmental conditions for tree growth have on the quality of the wood. In *Eucalyptus*, information on this relationship is scarce, especially when comparing

wood from identical genetic material, planted in different sites. The objective of this study was to compare the wood density and growth stresses of seven *Eucalyptus* clones of the same age, planted at two sites with different productivity conditions. For this, three trees were sampled from each of seven clones, at 7 years of age, planted simultaneously in Paraopeba (site of higher productivity) and Bocaiuva, both located at Minas Gerais State, Brazil. Growth stresses were assessed by the measurement of longitudinal residual strains (LRS) in standing trees, using an extensometer. For wood basic density (BD) assessment, discs were cut along the stems. The LRS ranged from 50 to 95 micrometers, while BD ranged from 0.513 g/cm^3 to 0.618 g/cm^3. All clones showed higher LRS and BD for Paraopeba, the site of greater productivity. The LRS can be estimated by the BD, according to the quadratic model with R^2 = 80% for Paraopeba and R^2 = 54% for Bocaiuva.

Bidimensional scanning by means of acoustic tomography of six trees in the park of Ducuara at the University of Tolima, Colombia. Lozano Botache, L., Fajardo García, C., Bonilla Vargas, J. (*Universidad del Tolima, Colombia; llozano@ut.edu.co; califaga@gmail.com; forest.lorena@gmail.com*).

The internal status of six stems or trunks of *Senna siamea* (Iam.) trees in the Ducuara park of the University of Tolima was evaluated by means of nondestructive and non-invasive methods using acoustic tomography. The selected trees were located in a busy area, which is why it was essential to reduce the risk of branches or the tree itself falling on people or park infrastructure. With this method the possible rot of the wood along the first two meters of each stem was detected. It was concluded that the trunks of these six trees were not affected by rot at the heights of 40, 80, 120, and 200 cm measured above the ground. In general, each tree showed bad scars due to inadequate pruning and cracks in branches which provoked infections and rot at the cuts and affects the equilibrium of the trees. It is recommended to use this evaluation technology because it is easy to apply and delivers reliable results.

What makes wood so attractive? Transforming consumers` emotions into material characteristics. Manuel, A. (*University of Freiburg, Germany; andreas.manuel@fobawi.uni-freiburg.de*), Leonhart, R. (*Institute of Psychology Freiburg, Germany; leonhart@psychologie.uni-freiburg.de*), Breinig, L. (*Forest Research Institute of Baden-Württemberg, Germany; lorenz.breinig@forst.bwl.de*), Broman, O. (*Luleå University of Technology, Sweden; olof.broman@ltu.se*), Becker, G. (University of Freiburg*, Germany; gero.becker@fobawi.uni-freiburg.de*).

Flooring and other wood products are highly attractive due to their surface appearance. Besides the structure and color of wood, knot patterns are significant features influencing consumer appreciation. In contrast, the wood processing industry grades their products based on technical parameters where such features are regarded as defects. However, for wood product marketing the importance of consumer`s choice will most likely increase. Consequently, product design should meet consumer preferences. The aim of this study is to (a) investigate consumer preferences regarding wooden floorings, and (b) link descriptive surface characterization with technical product parameters. Spruce boards were composed to represent floor samples, and virtual images were acquired via optical surface scanner sensors. A total of 165 virtual floor samples with different optical characteristics were produced to test in an online study (about 460 participants) where a random selection of 5 floor samples was evaluated with seven subjective criteria found in a preliminary study. Results of cluster analysis indicate that consumer groups with different preferences coexist, and surface characterization can be associated to technical parameters relevant for floor board production (sawing pattern, floor composition). This may help to achieve higher consumer satisfaction, added-value and reduced rejects during production in the industry.

The Utah biomass resources group: from the dragon wagon to mobile pyrolysis. McAvoy, D. (*Utah State University, USA; darren.mcavoy@usu.edu*).

Pinyon Juniper woodlands have grown to cover nearly 50 million acres of the Intermountain West. This expansion and densification has created a fuel buildup that poses a hazardous to landscapes and communities. By creating a value for this woody biomass, more acres can be treated. The Utah Biomass Resources Group (UBRG) seeks to develop technologies and markets to utilize woody biomass while diversifying rural economies, creating jobs, and producing home-grown fuels. This presentation will introduce the UBRG and detail our research and educational programs. The (UBRG) hosted Utah's first ever wood powered concert, with power supplied by Utah State University's mobile gasification unit known as the dragon wagon. The UBRG is currently conducting demonstrations of mobile pyrolysis, transforming woody biomass into biochar and bio oil in the field. The UBRG conducts research on biomass harvesting, pyrolysis, biochar, bio oil, cofiring and more. Through research and education, the UBRG is building knowledge and awareness to promote woody biomass utilization in the Intermountain West.

Indonesian fast-growing tree species as alternative raw material for forest industries. Mindawati, N., Bogidarmanti, R. (*FORDA, Indonesia; ninapulp@yahoo.co.id; rinabogidarmanti@yahoo.com*).

Recently, wood production from existing natural forests have been unable to supply wood industries due to productivity decreases. Meanwhile, wood production from plantation forests of *Acacia mangium, Eucalyptus pellita,* and *Falcataria moluccana* do not show significant increases in production due to site degradation and pest and disease attacks. To solve this problem, the Forest Research and Development Agency (FORDA), Ministry of Forestry has a program to enhance the productivity and to look for some promising alternative tree species. This poster is aimed at giving information about some fast growing species to consider as raw material alternatives for forest industries for both construction and pulp wood in Indonesia. Suggested species include *Anthocephalus cadamba, Anthocephalus macrophyllus, Octomeles sumatrana, Michelia champaca, Disoxylum mollissimum, Camnospermum coriaceum,* and *Cratoxylum arborescens* which are characterized as fast growing species with a cutting cycle 6–15 years. Silviculture techniques for these species have been studied but are still limited, so further research is needed to fulfil the raw material demand of forest industries in Indonesia.

Macroscopic characterization and dimensional stability in selected specimens of *Prosopis alba* Griseb. in the Chaco Region of Argentina. Molina Bejarano, A. (*Universidad Distrital Francisco José de Caldas, Colombia; alisson_molina@hotmail.com*), Moglia, J. (*Universidad Nacional de Santiago del Estero, Argentina; vieckymoglia@gmail.com*), Cadena, M. (*Universidad Distrital Francisco Jose de Caldas, Colombia; cademielro@hotmail.com*).

This paper evaluated the macroscopic characterization and determination of dimensional stability in selected specimens of *Prosopis alba* Griseb. located in Villa Angela, Chaco. Through descriptive analysis and design of a randomized complete block experiment with 2 × 4 × 2 factorial sampling, we determined the sapwood-heartwood proportion and presence of defects and variation in radial tree level. Under the agreement between the University District and the Universidad Nacional Santiago del Estero, we assessed the quality of solid wood for timber species and prospects of the Chaco region. The proportion of heartwood was 90.95% with an interspecific variation in sapwood and heartwood color. Blemishes were evaluated as the percentage of incidence. The average value of radial contraction was 0.074, tangential shrinkage was 0.123, and longitudinal contraction was 0.024. The Bonferroni test statistical model we used allowed us to infer the largest sector instability. The proportion of sapwood-heartwood turned out to be efficiently solid, and we used a representation of 9.05% sapwood as a desirable amount. The values indicate that the species is within a normal range for contractions and anisotropy, and its solid wood is suitable for applications and derived products as long as you perform a drying program appropriate to the species. The analysis identified the pieces that have a lower quality in terms of increased contractions.

Impact of compression and thermal modification on mechanical properties of silver birch and European aspen wood. Mottonen, V., Marttila, J., Heräjärvi, H. (*Finnish Forest Research Institute, Finland; veikko.mottonen@metla.fi; juhani.marttila@metla.fi; henrik.herajarvi@metla.fi*).

Combination of compression and thermal modification of wood is a potential innovation for improving the utilization rate of light weighted wood species in solid wood products. The objective of the study was to determine the effect of compression and thermal modification on the modulus of rupture, modulus of elasticity and Brinell hardness of silver birch (*Betula pendula*) and European aspen (*Populus tremula*) wood. The modifications were carried out in an industrial-sized pilot device capable of drying, compression, and heat treatment of sawn timber. Combinations of two different degrees of compression and two different temperatures of thermal modification were used. Differences were found in the relative increase of Brinell hardness between species, degree of compression, and thermal modification. Due to the variation in the location of densified peaks in the specimen profile, differences in Brinell hardness at different depths were observed as well. Both modulus of rupture and modulus of elasticity were clearly affected by compression and thermal modification. The relative improvement in mechanical properties as a result of densification was larger for lighter weighted aspen than for birch. To conclude, combined compression and thermal treatment shows high potential for improving the mechanical performance of silver birch and European aspen wood.

Evaluation of pellets fabricated from plantation wood and several agricultural crops utilizing x-ray densitometry. Moya, R., Aragón, S. (*Escuela de Ingeniería Forestal, Costa Rica; rmoya@itcr.ac.cr; stefag1091@gmail.com*), Valaert, J. (*Pelletics, Costa Rica; jorre@agrepforestal.com*), Tommasiello Filho, M. (*University of São Paolo-ESALQ, Brazil; mtomazel@usp.br*).

The objective of this study was to evaluate the density variation and surface quality of pellets manufactured from raw material such as wood and other tropical agricultural crops from Costa Rica. Visual x-ray evaluation of the pellets showed that a uniform surface can be observed and the pellet can be cataloged as good quality. Other pellets presented small irregularities which cataloged the pellet as moderated quality. Finally, easily visible cracks were observed in other pellets. Another aspect shown by the x-ray images were clearer areas in the pellets, indicating higher densities. The evaluation of the cross section showed three patterns of variation: high density around the surface, irregular density, and uniform density. The first pattern has a high density at the pellet surface and a lower density inside. The irregular density has high density values at any point at the pellet diameter, and the uniform density pattern presents similar values across the diameter. Two patterns of density variations were observed in longitudinal direction: uniform density and irregular density. The first type shows little variation throughout the length and the second pattern shows areas of high density mixed with areas of low density.

Premature failure of creosote-treated electricity transmission wood poles in Zambia. Ncube, E., Chungu, D., Ng'andwe, P. (*Copperbelt University, Zambia; enncube@yahoo.com; donald.chungu@cbu.ac.zm; pngandwe2002@yahoo.co.uk*), Kamdem, D. (*Michigan State University, USA; Kamdem@msu.edu*), Chongo, A., Mwale, E. (*Copperbelt University, Zambia; cnncsiro@yahoo.com; enzama@tsamail.co.za*).

Creosote utility poles (*Eucalyptus grandis* Hill ex Maiden) should remain in service for over 40 years, but most are being replaced after 10 to 15 years in Zambia. The aim of this study was to determine causes of premature failure. Analysis of utility pole replacement frequency in Kitwe and Kalulushi regions was undertaken during July-December annual maintenance windows in 2010 and 2011. Sixty four wood pole specimens of 0.9 m length and 15–20 cm diameter range were treated to determine uptake, penetration, and retention using the Bethel process. Wood shavings from each specimen were obtained from level 1 and 3 sapwood band from cambium to pith. The retention of creosote was determined by automated soxhlet extraction using diachloromethane solvent. Full sapwood penetration (96.53%) and 3.34 kg/m^3 preservative uptake were realized. However, sapwood retention (60 kg/m^3) was significantly lower than the standard (115 kg/m^3). The observed increase in utility pole replacement frequency with distance from Nkana mine (i.e., Mine township < Kitwe south < Kitwe North) to Kalulushi region suggest that emissions from mining suppress biotic activity. The study showed that despite full sapwood penetration, the concentration of active ingredients was below acceptable thresholds, thus are susceptible to biodegradation. The results transform our understanding on optimizing utilization of utility poles in Zambia and elsewhere.

Growth drivers within the firewood industry. Nybakk, E. (*Norwegian Forest and Landscape Institute, Norway; nye@skogoglandskap.no*), Rasmussen, C. (*Norwegian University of Life Science, Norway; Casper.rasmussen@umb.no*), Panwar, R. (*Northland College, USA; rpanwar@northland.edu*), Lunnan, A. (*Norwegian University of Life Sciences, Norway; anders.lunnan@umb.no*).

Traditional firewood is an important bioenergy source in both the developed and the developing worlds. Primary solid biomass accounts for approximately 10% of the world's total primary energy production. However, there has been little research on traditional firewood. This study examines the relationship among customer orientation, innovativeness, tenacity, risk taking,

growth willingness, and growth in low-technology micro firms. A survey was sent to 3 000 managers in the Norwegian firewood industry, and 514 usable responses were received. The findings showed that customer orientation, innovativeness, and tenacity have a significant effect on growth in micro firms. In contrast with earlier studies, we found no support for interaction effects among innovativeness, tenacity, risk taking, and customer orientation. Managers should increase their focus on customer needs with regard to the manner in which goods are delivered. Although firewood is the most significant source of bioenergy, there has been little research on business or management in this industry. To reach the ambitious goal of reducing carbon dioxide emissions, we must pay more attention to this industry. Furthermore, to promote further growth, policymakers should understand how the industry operates and develops.

Sustainable bio-energy development in Kenya. Oduor, N. (*Kenya Forestry Research Institute, Kenya; nelliecoduor@yahoo.com*), Maingi, D. (*Wanley's Consultancy Services, Kenya; drmaingi@gmail.com*), Githiomi, J., Anapapa, A. (*Kenya Forestry Research Institute, Kenya; josephgithiomi@ymail.com; anapapaa@yahoo.com*), Gachanja, M. (*Kenya Forests Working Group, Kenya; gachanja2000@yahoo.com*).

It is estimated that 90% of rural households in Kenya use fuel wood or charcoal, with fuel wood meeting the energy needs of over 93% of rural households and charcoal being the dominant fuel in urban households. A recent study on the demand and supply of wood products indicates that the country has a wood demand of 41.7 m^3 against a national supply of 31.4 million m^3. The demand for wood fuel (firewood and charcoal) is 35 million m^3 against a supply of 21 million m^3. Forecasts for a 20-year period for wood fuel indicate a 16.9% increase in demand and a 15.6% increase in supply by the year 2032, which signifies a gradually increasing deficit. This paper looks at the sustainability measures available to address this challenge. Some of them include on-farm cultivation of fast maturing tree species for energy from plant species such as *Acacia, Eucalyptus*, bamboo, and *Casuarina*; management and utilization of invasive plant species for energy such as *Prosopis*; and the development and production of energy efficient technologies for cook stoves for domestic households and small businesses. Strategies for an enabling policy environment will be evaluated too.

Forest leafy vegetables marketing and sustainable rural livelihood in Rivers State, Nigeria. Oladele, A., Aiyeloja, A. (*University of Port Harcourt, Nigeria; adekunle.oladele@uniport.edu.ng; aiyeloja@yahoo.com*).

Leafy vegetables from forests are capable of sustainably generating income and employment for rural populations. An investigation of wild vegetable marketing was conducted in Port Harcourt, Oyigbo, and Ahoada West local government areas of River State, Nigeria with well-structured and pretested questionnaires. Data were analyzed using descriptive statistics, net profit, rate of return on investment (RORI), regression, and sensitivity analysis. Weekly profits and RORI were: Port Harcourt city (₦1134.48k, 34.1%), Oyigbo (₦2152.2k, 30.9%), and Ahoada West (₦608.98k, 21.89%) with 1USD=160 Nigerian Naira (₦). *Gnetum africana* had the highest daily profit of ₦159.30k. Sensitivity analysis of RORI showed profits were threatened at various degrees of increasing cost: Port Harcourt (35%), Oyigbo (35%), and Ahoada West (25%). Multiple regression showed that education, market, startup capital and product supply sources significantly influenced profit margins at $\rho = 0.05$. Wild vegetable marketing showed potential for increasing household income and sustaining livelihoods. Research on domestication, improved marketing, and provision of cooperatives loans is recommended for sustainable marketing.

Energy value of wood residues from *Gmelina arborea Roxb.* and *Tectona grandis Linn. f.* Oluwadare, A. (*University of Ibadan, Nigeria; femioluwadare@yahoo.com*), Anguruwa, G. (*Forestry Research Institute of Nigeria, Nigeria; glo.vision@yahoo.com*), Sotannde, O. (*University of Maiduguri, Nigeria; femsot@gmail.com*).

Large scale wood conversion processes generate lots of wood residues, and disposal is a major challenge. Alternative use of these residues for value-added products including energy is of great importance in Nigeria. This study was conducted on wood residues from *Gmelina arborea* and *Tectona grandis* to determine their energy value and value-added chemical compounds. Sawdust of the wood residues were collected from Forestry Research Institute of Nigeria sawmill. Extractive-free sawdust (10 g) was prepared using ethanol-toluene solution according to ASTM standard D1107 while lignin (acid insoluble) was extracted using 72% H_2SO_4 and 1.25 N NaOH (alkaline hydrolysis method). Extracted lignin (EL) and sawdust samples were subjected to calorific test, elemental analysis (Mg, Ca, Al, Fe, Mn, Cu, Zn and Pb), and compositional analysis to determine the functional groups using atomic absorption spectrophotometer (AAS) and FT-IR, respectively. Heating value was higher in sawdust than extracted lignin but was statistically similar. The metals K, Mg, Ca, Mn, Fe, Pb, and Zn were detected in both sawdust and lignin but at reduced concentrations in EL. Aromatic and nitro compounds were present in the materials. Observed heating values and presence of various compounds show possible use of these wood residues for energy production and value-added products.

Non-timber forest products in the Atlantic Forest and Savanna in São Paulo state, Brazil. Ota, L. (*São Paulo State University, Brazil; lizmsota@gmail.com*), Carvalhaes, M.A. (*EMBRAPA, Brazil; mariana.carvalhaes@embrapa.br*), Zakia, M.B. (*Forestry Science and Research Institute, Brazil; zeze.zakia@uol.com.br*).

The objective of this study was to make an assessment of the most interesting NTFP that could make environmental plantings economically attractive, especially for small rural properties. We also assessed the obstacles that are found by those who work in these production chains. We listed 70 species from 32 families that provide a product from at list one of the following categories: alimentation, ornamentation, biochemistry products, medicinal products, and handcrafted products. We considered the pulp of *Euterpe edulis* Mart. the product on the list with the greatest potential. The main obstacles found in the production of NTFP were: (1) legislations that are too restricted or not adequate to small-scale producers; (2) difficulties in getting credits and financial aid for the forestry activity that has a medium/long term payoff and for landholders that do not have legal documentation proving the land ownership; and (3) the weak market of the NTFP that still has a lot of intermediaries that keep big part of the profits. Next step is to propose adjustments in the environmental and sanitary legislation and to propose some actions for the state to make it easier for the landholder to get access to credits and financial aids which will help to stimulate the NTFP markets.

Potential for promotable oil products identified by traditional knowledge on native trees in Burkina Faso. Ouedraogo, A. (*University of Ouagadougou, Burkina Faso; o_amade@yahoo.fr*), Lykke, A. (*Aarhus University, Denmark; aml@dmu.dk*), Lankoandé, B., Korbéogo, G. (*University of Ouagadougou, Burkina Faso; lankoandehatina@yahoo.fr; kgabin1@hotmail.com*).

Oil products from native trees are far from fully exploited in West Africa. Only well-known species like shea (*Vitellaria paradoxa* C.F.Gaertn.) and oil palm (*Elaeis* guineensis Jacq.) receive attention. We used quantitative questionnaires in 12 villages in Western Burkina Faso to assess the knowledge of four ethnic groups on 28 tree species and how their oil is used. Sixteen species were used the most. Among them, *Vitellaria paradoxa*, *Elaeis guineensis*, *Carapa procera* DC., *Pentadesma butyracea* Sabine, and *Lophira lanceolata* Tiegh. ex Keay received the most citations. Oils were used for soap (22%), food (21%), medicine (19%), body care (18%), and hair care (14%). Significant differences were found among ethnic groups concerning knowledge and preferences of oil products. Apart from the well-known species, *C. procera*, *L. lanceolata,* and *P. butyracea* appear to be promising species for promotable oil products and a number of less known species may show potential as well.

Development of center-bored outer-surface sealed timber drying method and evaluation of the drying energy consumption. Park, J., Chang, Y., Yang, S. (*Seoul National University, Republic of Korea; gentleice@nate.com; jang646@snu.ac.kr; sly1357@snu.ac.kr*), Eom, C. (*Korea Forest Research Institute, Republic of Korea; willyeom@forest.go.kr*), Yeo, H. (*Seoul National University, Republic of Korea; hyeo@snu.ac.kr*).

Large cross-sectional round timber of pitch pine (*Pinus rigida*) was dried after a center-boring process involving the drilling of a hole in the longitudinal direction in the central portion of the timber. In order to shorten the drying time, high-temperature drying was applied. Outer surface sealing on the timber was done to inhibit the occurrence of surface checks. In comparison with non-bored round timber drying as a control group, the drying time and energy required during the center-bored drying of timber were analyzed. To dry the control green round timber (Ø 140 mm) to moisture content (MC) of 11% required nearly 4 days, with defects such as surface check and end checks appearing. On the other hand, the center-bored timber was dried rapidly to MC 6% in 2 days without drying defects. High-temperature drying after a center-boring process, when compared to the drying of round timber, greatly reduced the drying time while also reducing the amount of energy required by more than 50%, and created no defects as well. It was confirmed that high-temperature drying after a center-boring process and after sealing the outer surface is a very efficient drying process as it reduces the drying time, required energy, and number of drying defects in large cross-sectional timber in this study.

Contribution of NTFPs in livelihood and carbon management in moist temperate forests of Kashmir Valley, India. Peerzada, I., Zargar, M. (*Shere Kashmir University of Agriculture Sciences & Technology, India; drishtiyak@gmail.com; peerzis@gmail.com*).

This study is being carried out in the moist temperate forests of Jammu and Kashmir (J&K) State of India. J&K is situated between 32.17° and 36.58° north latitude and 37.26° and 80.30° east longitude. It is well accepted that many NTFPs are critical for the livelihood of millions of people and also play an indispensable role in forest ecosystems. Hence, it is equally significant that they are sustainable managed. It is beyond doubt that the biggest threat to forests and forest products is illicit extraction, harvesting, and trade. It can be controlled to a great extent by providing alternative opportunities to forest dwellers through participatory and sustainable management of NTFP resources. It will also be helpful for better management of forests which can play an important role in carbon management, and thus, reducing the emissions from deforestation and forest degradation. Therefore, this study is designed to assess the role of NTFPs in livelihood improvement of forest dwellers and as a carbon management (REDD+) tool through people participation and protection measures.

Factors impacting exports of U.S. hardwoods: a case of study in Germany, China, and Vietnam. Quesada, H., Smith, B., Arias, E. (*Virginia Tech, USA; quesada@vt.edu; rsmith4@vt.edu; earias@vt.edu*).

According to the American Hardwood Export Council (AHEC), in 2011 the United States (U.S) exported over $2.5 billion in hardwood products, with 79% of those exports being lumber and logs. Main markets for U.S hardwood were Canada and Mexico (33.4% of demand), East and Southeast Asia (33%), and the European Union (27.2%). Traditional markets for U.S. hardwoods, such as Canada and Mexico, are well understood, and there are a lot of resources available to support exporters to this market. However, little is known about markets in East and Southeast Asia and also in the European Union. The goal of this research project was to investigate factors that impact the export of U.S. hardwoods to those two regions. More importantly, the identification of not just economic factors but also social and cultural factors that potentially could increase the exports of higher value-added products such as dimensioned lumber, veneers, and furniture over lower value-added products such as logs and lumber is also important for this research. Based on personal interviews to more than 40 hardwood importers in Germany, China, and Vietnam, data were collected and analyzed using qualitative and quantitative techniques. Main results indicated that there are a large number of unknown and unexploited opportunities for U.S. hardwood producers to increase value to their exports to these specific markets.

Phophine fumigation for protection of wood from powderpost beetle damage in Indian conditions. Ramdevi, O.K. (*Institute of wood science and technology, India; okremadevi@gmail.com*), Deepthi, T.R. (*Institute of Wood Science and Technology, India; deepthitrarun@gmail.com*).

Wood being an organic material is damaged by xylophagous insects both when it is in the tree and after it is harvest. In Indian log storage conditions, powderpost beetle (*Sinoxylon anale*) is the most devastating wood pest. Use of wood fumigation with phosphine to control wood boring insects is not being practiced in India. Different concentrations of phosphine were tested against adults of *S. anale* in desiccator tests. The mortality was 75% at 100 ppm, 85% at 150 ppm, and 100% at 200 ppm levels of the gas. LC50 was calculated as 61.73 ppm. In field trials using infested stacked logs of subabul and eucalyptus, observations were taken on the response of baited insects against different doses of phosphine. After 72 hours, samples of wood logs were removed from different levels of the stack, autopsied, and observations were taken on the effectiveness of phosphine on larvae,

pupae, and adults. All stages were found dead, indicating a good penetration of phosphine into the logs. The residue of aluminium tablets was found in the form of powder. The study indicated that phosphine fumigation can be adopted to cure the infestation of *S. anale* in wooden logs and products.

Platform for cost efficient environmental assessment. Raty, T. (*Finnish Forest Research Institute*, *Finland; tarmo.raty@metla.fi*).

The research on environmental performance of wood and communication of environmental performance shows low impact in industry. Recent market gains of the wooden multi-store houses are promising, but there are no signs that the environment has been the critical success factor. Our new initiative, Platform for Environmental Assessment (PEnA), was launched to promote the accumulation of environmental information and its usage in decisionmaking. It aims to improve the ability and willingness of wood product companies to communicate the environmental attributes by lowering the efforts needed to produce environmental information. The effects are sought by creating an open access database of environmental impacts and by developing data supporting environmental assessment tools. The database will first provide primary information about the stand-level carbon balance and its allocation to harvested wood, as well as generic descriptions of how it impacts the wood processing chain. The data can be extracted into the form of standard environmental product declarations (EPDs). The process of creating EPDs for wood products is cumulative and is facilitated by developed low entrance level environmental assessment tools reading the database and pointing for supplementary information. PEnA supports building information model (BIM), making it possible to compare the environmental impacts of alternative materials and constructions.

Use of medicinal plants among Panchen-Monpa tribe in remote region in the Eastern Himalayas, India. Saha, S., Chakraborty, T. (*University of Freiburg, Germany; somidh.saha@waldbau.uni-freiburg.de; tamalika.chakraborty@waldbau.uni-freiburg.de*).

This paper reports on ethnobotanical use of herbaceous plant species combined with ethnopharmacological approaches among the Monpa people of remote Zemithang region, Arunachal Pardesh, Eastern Himalayas. The previous works on ethnobotanical uses of plants in the Eastern Himalayas of the Arunachal Pradesh mainly covered up to the forests of the lesser Himalayas. But this research focused on more high altitude sites in the Northeastern Himalayan subalpine region. It was also the first comprehensive ethnobotanical and ethnopharmacological research on the Monpa people of Zemithang region, living at the extreme of north-western Arunachal Pradesh along the border with China and Bhutan. The participatory transect walk and interviews and discussions with traditional healers were used for ethnobotanical and ethnopharmacological data collection. We described 53 plant species from the study area which are being using in traditional medicine. We documented and described 24 ethnomedicines prepared for healing purposes from these 53 plant species. These traditional medicines were most commonly used to heal a wide range of diseases such as: arthritis, rheumatic pain, malaria, cough and cold, and dysentery. We also documented ethnopharmacological prescriptions for epilepsy, herpes, and oedema rarely found in past studies. Our studies showed the high importance of documenting traditional knowledge.

Potential of non-timber forest products in Perum Perhutani. Sambodo, C., Muharyani, N. (*Perum Perhutani, Indonesia; corrysambodo@yahoo.com; novincimuharyani@yahoo.co.id*).

Perum Perhutani, is a state-owned forestry enterprise in Indonesia with a management area in Java and Madura island that covers 2 426 207 ha of forest area. This area has a large number of non-timber forest products (nTFPs). Based on regulations issued by the Indonesian Ministry of Forest, NTFPs are defined as non-timber forest products collected from protected forest or production forest areas. The corporate policy is focused on forest chemical products, forest food and health products, ecotourism, and landscape beauty. The mainstay of NTFPs in Perhutani are pine resin (483 272 ha production area), gum rosin (produced 71 976 tons in 2011) and turpentine (produced 15 353 tons in 2011), while the NTFPs that need to be developed are honey, *Amorphophallus*, medicinal plants, alternative energy sources, and ecotourism. Contribution from these products covered 42.5% of total revenue for the company in 2011, showing that NTFPs are a promising forest product.

Endophytic fungi as a source of bioactive compounds. Sarjala, T. (*Finnish Forest Research Institute, Finland; tytti.sarjala@metla.fi*).

All higher plants are generally hosts to endophytic bacteria and fungi, which live in the intercellular spaces of the plant tissues. They constitute a vast and largely untapped source of secondary metabolites, which may be potential novel drugs. Secondary metabolites are often involved in a host-endophyte relationship and contribute to the protection of the host. Endophytes are known for their bioactive compounds with cytotoxic, antitumor, anti-microbial, neuroprotective, antioxidant, and anti-inflammatory activities. The rationale for studying endophytic microbes as a source for new medicines is related to the fact that it is still a relatively unexplored area. In Finland, trees that are growing in drained peatland forest sites may face several abiotic stress conditions such as drought, flood, and limitations of nutrients. In these sites we have found endophytic root-associated fungi in Scots pine to be very common in comparison with typical ectomycorrhizal species which are normally abundant in the tree roots on mineral soils in Finland. Under harsh conditions, the endophytic fungi may have a protective role in the hosts, and we assume that drained peatland forests may serve as a big reservoir of endophytic fungi with bioactive potential for novel drug development.

Key problems of the use of environmental-friendly straw board in furniture production: some countermeasures. Shen, L. (*Nanjing Forestry University of China, China; shenlimingda@hotmail.com*), Lewark, E. (*University of Freiburg, Germany; siegfried.lewark@fobawi.uni-freiburg.de*), Yu, N., Zhu, Y., Zhong, S. (*Nanjing Forestry University, China; yuna96@hotmail.com; zhuyun0911@163.com; sluzh@163.com*).

Straw board is a new kind of panel, using straw from agricultural production as the main raw material. It is free of formaldehyde, and therefore belongs to the new environmentally friendly furniture materials. But due to the significant differences among straw board, particle board, and medium density fiber board in mechanical properties, mechanical processing performance, surface

quality, etc., it is difficult to replace these boards with straw board in furniture production. The three key problems of the straw board use in furniture production are discussed, namely the veneer and edge banding technology, surface treatment and coating technology of straw board, and the type and strength of joints of the straw board furniture component. Based on the results of experiments, joint types were developed which increases joint strength in straw board furniture. The relationship between paint film adhesion, surface quality of the straw board, and the coating process has been determined. Methods of improving the straw board surface decoration quality and dimensional stability was developed. The results provide basic information for the application and promotion of the new environmental friendly straw board in furniture production.

Main non-timber forest products socio-economic importance for inhabitants of the Czech Republic. Šišák, L., Kupcak, V., Jarský, V., Riedl, M. (*Czech University of Life Sciences Prague, Czech Republic; sisak@fld.czu.cz; kupcak@fld.czu.cz; jarsky@fld.czu.cz; riedl@fld.czu.cz*).

We present an analysis of the socio-economic importance of free gathering of main non-timber forest products (NTFP) by inhabitants of the Czech Republic (CR) in 1994–2012. Gathering and use of NTFP in the CR has been systematically analyzed every year since 1994, always using basically the same methodology of personal questionnaire surveys, interviews with representative samples of inhabitants of the CR, and quota selection. The importance of edible mushrooms and main forest berries (bilberries, raspberries, blackberries, cowberries, and elderberries) was investigated. The results showed high importance of NTFP for inhabitants of the CR. Investigations proved that the majority of the inhabitants and households in CR gathered NTFP. On average, 10.7 kg of main NTFP were gathered annually by a household in 1994–2012, which amounts to 38.9 million kg and 143.3 million EUR in the total CR. The value is about 1/6 of the average timber harvest annual value. Nevertheless, the amounts of NTFP collection fluctuate substantially between individual years. A comparatively small part of the population gather NTFP to save money (about 12%), and an even lower share sells NTFP in the market (1.5%).

Evaluation of environmental impacts for Korean harvested wood products. Son, W. (*Korea Forest Research Institute, Republic of Korea; tistructure@forest.go.kr*), Kang, K. (*EcoServices Consulting Co., Ltd, Republic of Korea; kyungseoky@ecoservicesi.com*), Park, J., Park, M. (*Korea Forest Research Institute, Republic of Korea; jusang@forest.go.krmjpark@forest.go.kr*).

Establishing the environmental impact or carbon footprint of products has been important and is required as global warming and climate change have become world issues. To achieve this, a methodology of life cycle assessment (LCA) which can quantitatively calculate the environmental impacts of products and services throughout its life cycle, has begun to emerge. Therefore, this study performed LCA of harvested wood products (HWP) in Korea in order to determine greenhouse gas (GHG) emissions of HWP and amount of carbon storage. Function and functional unit of target system are respectively defined as manufacturing HWP used for secondary products or timber frame buildings, and a cubic meter of the target products. System boundary includes afforestation and transportation for round wood and manufacturing processes such as sawmill, drying, and processing for HWP. In addition, raw materials, ancillary materials, and energy usage as well as air emissions and wastes are collected in each unit process. Although the target system has multiple input and output processes, collectible data of energy usage are managed as integrated data. For dividing undistributed energy usage, this study considered specifications of machines such as motor power and feeding speed, and annual production time per product. The results of this study can establish the environmental impacts of target products during its life cycle and propose improvements for HWP.

Dynamic characteristics of 25 Mexican woods with a potential for structural use evaluated by stress waves. Suárez-Béjar, G., Sotomayor-Castellanos, J. (*Universidad Michoacana de San Nicolás de Hidalgo, Mexico; gezzoster@gmail.com; madera999@yahoo.com*).

There is a great number of wood species in México with a potential for use in structures and construction. Some of these species are being over-exploited to the point of endangerment, subutilized, or are commercialized only as raw materials. A contribution to the solution of this problem is providing, through research, technological data about Mexican woods. The objective of this study was to determinate density, speed of stress waves, and modulus of elasticity for 25 wood species. These species were studied using stress waves techniques. For each species, 20 specimens were tested. The specimens were 50 mm × 50 mm × 500 mm. The average moisture content was 10 percent. The densities ranged from 338 kg/m^3 to 1147 kg/m^3. The speeds of wave ranged from 3 007 m/s to 5 181 m/s, and the moduli of elasticity ranged from 3 053 MPa to 17 532 MPa. The variability shown in the results is due to the different densities of the wood. It can be concluded that the development of a different approach in the evaluation techniques of wood products, acceptable from an ecological and social point of view, will aid to promote an increase in the use of the Mexican wood as a structural and construction material.

Protecting forest and medicinal plant resources: a legal brief on *Prunus africana*. Suka, E. (*Ministry of Environment, Protection of Nature and Sustainable Development, Cameroon; emmanuelsuka@yahoo.com*).

Access is open to forests in Sub Saharan Africa for collection of medicinal plants including *Prunus africana* for local use and export to cosmetic and pharmaceutical industries abroad. The bark and roots treat many ailments, particularly human prostate cancer. The plant is endemic to Africa with high altitude characteristics known to exist only in Cameroon, Kenya, and Madagascar. It is exploited extensively and unsustainably to meet high demands by pharmaceutical companies in developed countries. Unfortunately, national legislatures do not have regulatory instruments for sustainable medicinal plant collection and trade. Methods used are based on the best available technology taken from integrated agroforestry and on-farm medicinal plant domestication and cultivation. Documents and texts consulted included 1992 Convention on Biological Diversity/protocols, 1973 Washington Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and World Trade Organization (WTO). Government officials and local communities holding important traditional knowledge on medicinal plants were also consulted. Multilateral instruments above are not fully implemented. Forests and medicinal plant resources can be conserved and benefits sustained in the long term if contracting parties legislate and implement CBD, CITES texts and protection provided by WTO for Intellectual Property Rights of Indigenous People's Knowledge and trade on genetic resources.

Saving blood fruit and monkey cola from disappearing in Cameroon's forest. Suka, E. (*Ministry of Environment, Protection of Nature and Sustainable Development, Cameroon; emmanuelsuka@yahoo.com*).

Blood fruit (*Trichoscypha arborea*), an Anarcardiaceae, and Monkey cola (*Cola pachycapa*), a Sterculiaceae, are primary forest fruit trees in Cameroon among many other non-timber forest products that are threatened. Their fast disappearance away from the tropical forest of Africa is alarming partly due to insufficient knowledge and financial means for their management, and fully due to exacerbated pressures from unorthodox forest exploitation and massive unsustainable agricultural systems. These forest fruit trees have zero conservation status despite their environmental, social, and economic importance in the livelihoods of forest dwellers and forest dependent communities. *Trichoscypha arborea* fruits per se are a source of vitamins valuable to diets for food security in addition to its blood provision qualities critical to health that the pharmacology industry has yet to research. To ensure sustainable management and conservation of these species, a holistic method using an environmentally sustainable and socially inclusive approach was used with adoption of on-farm multiplication and cultivation through agroforestry systems in the area. Research results contributed to forest conservation and REDD+ objectives, thereby mitigating climate change effects. Conserving forest fruit trees promotes wise forest use and adaptation strategies that provide alternative incomes and incentive to rural communities that improve their livelihoods, local economies, and sustainable development.

Physical and chemical characterization of three hardwood species with potential for commercial use. Takeshita, S., Andrade, A., Jankowsky, I. (*University of São Paulo-ESALQ, Brazil; takeshita.sa@gmail.com; ariel@anpm.org.br; jankowsky@usp.br*).

Nowadays the search for a sustainable source of raw material is the focus of numerous studies. Among several alternatives, wood stands out because it is a natural resource, renewable, reusable, and recyclable. However, the only commercially known species are used on a large scale. Thus, the purpose of this research was to carry out physical and chemical characterization of three potential species for commercial use so they may become an alternative to avoid more intensive exploration of only a few species. The species studied were *Erisma uncinatum Warm*., *Tachigali myrmecophyla* (Ducke) Ducke, and *Lecythis usitata* Miers. The characterization of specific gravity and dimensional changes was conducted according to Brazilian Standard NBR 7190. Chemical analysis determined glucose, xylose, arabinose, and galactose using HPLC (high performance liquid chromatography). Extractive and lignin content were also determined according to TAPPI T204 cm97 and TAPPI T222 om02, respectively. As a result, the specific gravity of *Erisma uncinatum, Tachigali myrmecophyla,* and *Lecythis usitata were* 0.56, 0.62, and 0.88 g/cm³. The lowest dimensional changes were presented by *Lecythis usitata,* however cracks were observed during drying. In general, these species present potential for commercial uses and can be introduced into the market.

Dimensional changes in behavior of *Erisma uncinatum* Warm. submitted to additional heat treatment at 90 °C after conventional drying. Takeshita, S., Jankowsky, I. (*University of São Paulo-ESALQ, Brazil; takeshita.sa@gmail.com; jankowsky@usp.br*).

Defects such as warping and cracking presented by wood are the result of their hygroscopic character and consequent dimensional changes. To minimize this effect, wood is submitted to air drying or kiln drying processes, but hygroscopicity is not completely eliminated. The purpose of this research was to evaluate the effects of an additional heat treatment at 90 °C after kiln drying on the reduction of dimensional changes in the of wood of *Erisma uncinatum* Warm. This temperature was chosen so it is possible to apply the treatment in practice, using existing equipment in industries. After the kiln drying processes, the samples will be submitted to 90 °C temperatures with different combinations of time, and then they will be conditioned in an environment of low relative humidity (between 20–30%) followed by an environment of high relative humidity (between 80–90%) to evaluate the effect of treatment on the rate of wood sorption and its dimensional changes. It is expected this will result in a decrease in the dimensional changes due to the application of the additional heat treatment to improve the quality of the final product, thus reducing rework and waste of raw material resulting from incidence of defects.

Plants used to treat infectious diseases in Togo: *Pterocarpus erinaceus* Poir (Faboïdeae) and *Daniellia oliveri* (Rolfe) Hutch. and Dalz (Caesalpinoïdeae). Tittikpina, N., Gbogbo, K., Agban, A., Hoekou, Y. (*University Of Lome, Togo; Knassifa@yahoo.fr; kagbogbo@gmail.com; agbanamegninou@yahoo.fr; patrick21h@yahoo.fr*), Pereki, H. (*University of Lome, Togo and Hamburg University of Applied Sciences, Germany; pereki@daad-alumni.de*), Batawila, K., Akpagana, K.

This study was run to identify plants used to treat infectious diseases due to *Candida albicans* and *Staphylococcus aureus* in the central region of Togo. A semi-structured ethnobotanical survey showed that the most used plants by traditional healers are *Pterocarpus erinaceus* and *Daniellia oliveri*. The plant parts commonly used are barks and roots. The extraction on the roots, barks, and leaves of these two plant species was realized using two different means: an exhaustive, successive extraction and a crude hydro-ethanol extraction. The antimicrobial activity tests, using a broth dilution coupled with the spread on agar, confirmed that all the plants parts were active against the two pathogens, but their leaves were the most efficient with a MIC ranging from 1.875 mg/mL to 7.5 mg/mL. The phytochemical study has shown the presence of alkaloids, flavonoids, saponins, tannins, and anthraquinone compounds in the plant extracts. The results confirm the use of *Pterocarpus erinaceus* and *Daniella oliveri* as anti-infectious diseases agents and propose the use of their leaves as an alternative to prevent their disappearing.

Case study: impact of climate change on industrially relevant white spruce wood traits determined with SilviScanTM. Tong, T. (*FPinnovations, Canada; Tessie.Tong@FPInnovations.ca*), Beaulieu, J. (*Natural Resources Canada, Canada; jean.beaulieu@NRCan.gc.ca*), Sherson, G. (*FPInnovations, Canada; gail.sherson@fpinnovations.ca*).

Climate change affects not only tree growth and survival but also wood quality. Given the importance of wood quality and resulting product performance to the economic values of forests, it is imperative to understand how wood quality responds to climate change. Advanced technologies such as SilviScan are available for research into impacts of climate change on industrially relevant wood traits. SilviScan rapidly and cost-effectively determines multiple wood quality traits on the same increment core or wood disc sample, offering high-resolution pith-to-bark measurements. In this case study, transfer models were developed to establish the relationship of white spruce wood quality traits with transfer distances for 17 annual climate variables. Wood

samples were selected from 3 planting sites and 21 provenances in eastern Canada. Quadratic regression analyses showed that variation in wood quality traits between provenances is large, reflecting the significant genetic control of wood traits. The study also revealed a significant impact of climate change on wood quality traits, even with the restricted range of climate values available in the study. For example, total annual precipitation alone accounted for 18% of the variation in fiber coarseness, one of the key fiber attributes impacting pulp and paper product performance.

Longitudinal and radial variation of the charcoal production in eucalypts. Trugilho, P. (*Federal University of Lavras, Brazil; trugilho@dcf.ufla.br*), Arantes, M. (*Federal University of Espírito Santo, Brazil; mdonaria@hotmail.com*), Lima, J., Silva, J., Paula, L., Neto, R.G. (*Federal University of Lavras, Brazil; jtlima@dcf.ufla.br; jreinaldo@dcf.ufla.br; luanafloresta@hotmail.com; rmgnetto@yahoo.com.br*).

This research aimed to determine the longitudinal and radial variation of the charcoal production in one hybrid clone of *Eucalyptus grandis* x *E. urophylla* in three diametric classes. A total of 34 trees were used made up of 22, 9, and 3 trees in the 14.2 cm, 11.4 cm, and 8.1 cm diameter classes, respectively. The longitudinal sampling consisted of removing discs at 2, 10, 30, and 70% of the commercial height, up to 5 cm in diameter. The radial sampling was performed on the disks at up to five positions (20, 50, 70, 80, and 90% of the radius), depending on the diameter of the discs. The results indicated that charcoal production was reduced from pith to bark and with tree height in all diameter classes. Larger variations in both radial and longitudinal charcoal yield occurred in the largest diameter classes (14.2 cm and 11.4 cm). In the 14.2 cm class, higher values of charcoal yield occurred at 10% of the commercial height at 20, 50, and 70% of the radius; however for the classes of 11.4 cm and 8.1 cm classes, the highest yields were at 2% tree height at 20 and 50% of the radius.

Production of mate (*Ilex paraguariensis*) in Rio Grande do Sul, Brazil in the last years: discussing the current crisis. Vassali, M. (*Federal Rural University of Rio de Janeiro, Brazil; mauriciovassali@gmail.com*), Lopes, M. (*Federal Rural University of Rio Grande do Sul, Brazil; manoelasm@gmail.com*).

Since before the first settlers arrived in Brazil, mate (Ilex paraguariensis St. Hil.) was used by the natives. Today, the culture of tea mate persists, especially in the southern region of the country. In keeping with tradition, the main form of exploitation is the extraction of the culture, of which approximately 700 000 acres are intended for the production of mate with more than 95% of it in southern Brazil. The economy generates hundreds of thousands of jobs, although not always legally, using few chemicals and assisting the maintenance of forests, being one of the most sustainable in the scenario. With the current crisis of production and the increasing price of the product on the market in RS state, this work aimed to raise the amount of mate produced in planted areas according to SINDIMATE data from between 2001 and 2010 as a way to initiate a discussion on this important subject. The results showed that, although the amount produced has remained relatively constant since 2007, the planted area was reduced by at least 30% in the period of 2007–2010, which can be explained by the long time for the plant to get ready for production and low trade price in recent years.

Wood materials and products in the development of bio-economy: RDI program of the Finnish Forest Research Institute (METLA). Verkasalo, E., Heräjärvi, H., Hänninen, R., Kärkkäinen, K., Lindblad, J. (*Finnish Forest Research Institute, Finland; erkki.verkasalo@metla.fi; henrik.herajarvi@metla.fi; riitta.hanninen@metla.fi; katri.karkkainen@metla.fi; jari.lindblad@metla.fi*).

The wood products sector is in a key position to develop bio-economy. Novel business concepts, products, services, and life cycle thinking are expected to increase the competitiveness of the enterprises of the sector. The growing demand of goods and services in the building and living logistics sector as well as bio-refineries call for increased understanding and efficiency in production and management of wood-based material streams. Knowledge-based renewal created by research, development, and innovation (RDI) is the key success factor for the sector, through better customer orientation and profitability in the entire value chains and adoption of good practices from the neighboring sectors. Finnish Forest Research Institute (Metla) recently launched the RDI program, Wood Materials and Products in the Development of Bio-Economy (2014–2018). The aim is to create a basis for the Finnish bioeconomy through the wood products sector and new opportunities for the enterprises in the context of bio-economy. The program includes five themes: 1) wood products sector in bio-economy; 2) wood utilization, products, and services; 3) raw materials and side-streams; 4) measurements; and 5) genetics and quality. The first themes have a more applied character, whereas the last themes focus more on basic research. METLA is seeking international project collaboration in these themes.

Biomass supply chains: mapping flows and identifying forest sector business opportunities. Vlosky, R. (*Louisiana State University, USA; vlosky@lsu.edu*), Kolluru, R., Smith, M. (*University of Louisiana at Lafayette, USA; kolluru@louisiana.edu; mxs2356@louisiana.edu*), D'Agostino, C. (*Louisiana Business & Technology Center, USA; cdag@lsu.edu*).

We will provide results of an integrated research and outreach effort to identify potential alternative bio-based revenue and profit streams of members of the forest sector supply chain in Louisiana, USA. We mapped the supply chain for forest products in Louisiana and identified potential wood-based bio-business options that can be integrated into supply chain member current business models to enhance profitability and diversify revenue streams. Forest and production mill residues and dedicated forest biomass production were the focus of the project. We used a mixed mode phone interview and mail survey methodology to identify current and potential business positions and identify willingness to participate in new wood bio-based business opportunities. The outreach component consisted of two business education workshops designed to increase target audience understanding of options and opportunities, provide guidelines and advice on how to proceed if they are interested in pursuing alternative business strategies, and provide potential matchmaking linkages to potential business partners in forest-based bio-based ventures.

Wood-based biomass-to-electricity sector development in rural Uttarkhand, India. Vlosky, R., Mishra, A. (*Louisiana State University, United States; vlosky@lsu.edu; amishr3@tigers.lsu.edu*).

This study examines the social, technical, and economic viability of forest biomass-gasification-electricity businesses in rural Uttarakhand, India. A survey of rural households was conducted to understand their energy needs, perception about biomass

power, and willingness to participate in the briquetting business. In addition, other stakeholders were interviewed, including scientists from the Indian Institute of Science, the Energy Research Institute, and local/state politicians, to understand current plans and potential future support for this business model. The economic viability of different scenarios was also examined by evaluating net present value (NPV) and internal rate of return (IRR).

Consumer perceptions of children's furniture in Shanghai and Shenzhen, China. Wan, M., Toppinen, A., Chen, J. (*University of Helsinki, Finland; minli.wan@helsinki.fi); anne.toppinen@helsinki.fi; jzchen@mappi.helsinki.fi*).

With the improvement of living standards, Chinese people are increasingly concerned about their life quality, especially when buying consumables like clothing and durables like furniture for their children. In the past 10 years, the Chinese children's furniture market has developed rapidly. However, no studies concerning the analysis of consumer behavior in this market segment exist yet. The objective of this study was to fill this gap by examining consumer perceptions of children's furniture by conducting quantitative surveys in Shanghai and Shenzhen in China in 2012. The data revealed that 67% of the 299 respondents were females, and 63% and 23% of respondents were in the range of 31–40 and 20–30 years old, respectively. Results indicated that eco-friendliness, use of natural materials, and safety were the primary consideration for parents in buying children's furniture. Consistent with this finding, 83% of respondents chose solid wood as the primary raw material for children's furniture, and 98% of respondents were willing to pay premiums for eco-friendly children's furniture. Nevertheless, Chinese consumers had low brand awareness and their price expectations on solid wood furniture were below current market levels. Despite these concerns, children's furniture presents a growing high-end market potential for both furniture producers and wood raw material suppliers.

Nondestructive estimation of mode I fracture toughness of wood using near infrared (NIR) spectroscopy. Watanabe, K., Ukyo, S., Hiramatsu, Y., Yamada, T. (*Forestry and Forest Products Research Institute, Japan; kenwatanabe@affrc.go.jp; ukyo@ffpri.affrc.go.jp; yash@ffpri.affrc.go.jp; yamadat@affrc.go.jp*), Kambe, W. (*Kanto Gakuin University, Japan; wkambe@kanto-gakuin.ac.jp*).

This study investigated the application of near infrared (NIR) spectroscopy to estimate fracture toughness of wood. One hundred air-dried Sugi (*Cryptomeria japonica*) samples were prepared and NIR spectra were obtained from transverse, radial, and tangential surfaces of each sample. The critical stress intensity factor of mode I (K_{IC}) was measured by single-edge-notched bending tests. Partial least squares (PLS) regression models were developed for estimating K_{IC} using the NIR spectra collected from each surface and validated by leave-one-out cross-validation. The spectra collected from the transverse surface gave a better prediction than the ones collected from radial and tangential surfaces. The relationships between measured and estimated K_{IC} were good with a coefficient of determination of 0.62 and a root mean square error of 0.017 MPa/m^2. These results indicate that NIR spectroscopy has the potential to estimate K_{IC} of air-dried Sugi samples.

Contradictive dragon blood rattan: promising people livelihood, conversely, species in the doorway of extinction. Widyati, E. (*FORDA, Indonesia; enny_widyati@yahoo.com*).

Dragon blood (DB) is a reddish-purple resin extracted from young rattan fruit of *Daemonorops* genera. This resin is usually utilized as a traditional medicine, cosmetics, and dye agent. DB has been a hereditary livelihood of the people in Sumatera and Borneo. The product was mostly exported to China. Until now, a global demand for DB did not exist. Consequently, the price is getting higher and higher. At the farmer level, the best grade of DB reaches 400 US$/kg. This paper discusses some identified obstacles in utilizing DB rattan sustainably. Data were collected based on field studies, interviews, statistical data from local governments, and related published studies and reports. Studies carried out in South Sumatera and Jambi Province showed that rattan fruits supplying DB customarily come from wild harvest. The increased deforestation during the recent decade has decreased the natural populations. However, cultivation efforts to satisfy the supply have encountered some limitations. People prefer to harvest the young fruits for producing resin rather than harvesting the mature fruits for a seed source, causing regeneration stock to become a big problem. Other problems were lack of information on its natural potential, phenology, seed handling, market regulation (both seed and resin), and community perception.

Soil contamination with chromated copper arsenate preservative, an organophosphate and two synthetic pyrethroids affecting seed germination of okra and tomato vegetables. Wong, A., Bulan, P., Tawi Anak Daud, C. (*University of Malaysia-Sarawak, Malaysia; awong.unimas@gmail.com; petrus@frst.unimas.my; carlsontawi@gmail.com*).

Careful handling and use of wood protecting chemicals helps to safeguard the surrounding soil (groundwater) environment in any operational wood treatment process and with long-term exposure of treated wood in service. A study was done on the effects of both filter paper and red-podzolic soil contaminated with chromated copper arsenate (CCA) preservative and water-borne termiticides chlorpyrifos, cypermethrin, and permethrin on the seed germination rate of okra (*Abelmoschus exculentus*) and tomato (*Solanum lycopersicum*) vegetables seeds. Results overall, irrespective of filter paper or soil substrate, revealed that seed germination rates were affected by increased chemical concentrations and corresponding acidities of CCA and chlorpyrifos contaminated solutions. CCA preservative was much more phytotoxic than chlorpyrifos, while the synthetic pyrethroids showed no observed phytotoxic effect. Extrapolating, from an environmental perspective CCA preservatives and chlorpyrifos, but probably not permethrin and cypermethrin, could pose serious threats to the soil (i.e., groundwater) environment and affect seed germination of certain plants if chemical spillage due to mishandling or to leaking storage devices or if possible long-term leaching of such treated wood into soil occurs.

Soil contamination with aqueous wood extractives does not inhibit seed germination of okra and tomato vegetables. Wong, A., Tan, W., Bulan, P (*University of Malaysia-Sarawak, Malaysia; awong.unimas@gmail.com; weikhong90@hotmail.com; petrus@frst.unimas.my*).

A study was done on the effects of contamination of both filter paper and red-podzolic soil with aqueous heartwood extractives of Sarawak-Malaysian wood species kempas (*Koompassia malaccensis*), Belian (*Eusideroxylon zwageri*) *Acacia mangium,* and

extractives of undifferentiated wood of Engkabang jantong (*Shorea macrophylla*) on seed germination rate of the vegetables okra (*Abelmoschus esculentus*) and tomato (*Solanum lycopersicum*). Among these woods, Belian heartwood extractives are well-known for conferring the natural durability of the wood. Phytotoxicity tests revealed variable seed germination rates of both plants depending on the seed quality and extractive types/concentrations of cold water and hot water extracts contaminating the filter paper and soil substrates. However, the highest concentrations showed no observed inhibitory effects on seed germination. This suggests that in reality, concerns of leaching of aqueous wood extractives from externally stored raw wood materials (including logs, sawnwood, wood chips, and sawdusts) or wood pulping processes, even from a naturally durable wood, into surrounding soil environment (as groundwater contamination) may not necessarily pose phytotoxic threats to certain plant species.

Bamboo shoots sector in China: encountering a great opportunity with some challenges. Wu, L. (*China National Bamboo Research Center, China; boteatree@163.com*), Li, R. (*Zhejiang University, China; zhedalirui@zju.edu.cn*), Gao, G., Zhong, H. (*China National Bamboo Research Center, China; anshu998@163.com; zhonghao0726@163.com*).

Bamboo, with two main products of bamboo timber and bamboo shoots, is one of the earliest non-wood natural resources developed and used by human beings. Bamboo shoots are rich in protein, high in fiber, low in fat and calories, and are used as a delicacy in human food. With a good reputation both in domestic and international markets, China has achieved a rapid development of the bamboo shoots sector in the past 30 years. This article briefly introduced the bamboo shoots resource in China and the nutritional and medicinal value of bamboo shoots. An analysis and classification was taken of the history and achievements of bamboo shoots cultivation and utilization in China. The emphasis was put on the problems and changes in the development of the bamboo shoots sector in China in order to promote further progress. In summary, the suggestion and orientation of the bamboo shoots sector were proposed for China and the world.

Effect of different surface treatment processes on the printability and absorbability of decorative base paper. Xu, J., Long, L., Peng, X. (*Chinese Academy of Forestry, China; xujianfeng198216@aliyun.com; longling@caf.ac.cn; pengxr@caf.ac.cn*).

Wood-based panels overlaid with decorative paper are rich in color, beautiful, and have excellent visual effects. Decorative paper can protect wood-based panel from wear, heat, and contamination. So the properties of decorative base paper, especially the printability and absorbability, directly affect the quality of wood-based panel products. The former affects the print quality and the latter affects the absorption of melamine in the production of decorative paper. In this paper, the way to get excellent printability and absorbability of decorative base paper was studied. Three types of mixture including starch, starch and styrene acrylic ester (SAE), and starch and polyurethane (PU), were respectively used in the surface-treatment of decorative base paper. The effect of the kind of mixture and the dosage of each component on the printability and absorbability of paper were investigated. The results showed that excellent surface-treatment effects were obtained when starch and SAE with a mass ratio of 20:1 was used. Compared with the value of paper without surface-treatment, the tensile strength increased by 40% and smoothness doubled. Meanwhile, color density was higher and absorbability was maintained.

Forest products trade and wood carbon flows: case study of forest product trade between U.S. West Coast and China. Zhou, X. (*U.S. Forest Service, USA; xzhou@fs.fed.us*), Yang, H. (*Nanjing Forestry University, China; yhqnfu@gmail.com*).

Forest products in transit carry massive amounts of wood carbon. The trade of forest products leads to the flow of carbon stored in the wood in or out of the countries involved. The accounting of wood carbon flow among trading parties will have a significant impact on total carbon estimates in the forest sector for the trading countries. Over 65% of the U.S. log export and about 27% of the U.S. lumber export were shipped out from the West Coast during the second quarter of 2013. China has been a major forest product trade party to the U.S. West Coast since 2008. This study will track the forest products trade between the U.S. West Coast and China to show the wood carbon flow from the trade and the impact on the total forest carbon estimation among trading parties in the forest sector.

GENERAL POSTER SESSIONS

IUFRO Division 6: Social Aspects of Forests and Forestry

Participation of stakeholders in community-based forestry in Cross River State, Nigeria. Abi, E. (*Forestry Research Institute of Nigeria (FRIN), Nigeria; eneabi2008@yahoo.com*), Babalola, F. (*University of Pretoria/University of Ilorin, South Africa; Fola.Babalola@up.ac.za*), Ibor, O. (*University of Calabar, Nigeria; otu_crs@yahoo.co.uk*).

Participation of stakeholders is pertinent to effective implementation of community-based forestry (CBF). This study therefore evaluated the participation of and working relationships between timber dealers and forestry officials in implementing CBF in Cross River State, Nigeria. Primary data were collected through administration of a structured questionnaire to the forestry officials in the local communities where CBF is practiced, as well as to the timber dealers involved in harvesting, transportation, and processing of timber resources obtained from community forests under CBF. As stakeholders in CBF, forestry officials are responsible not only for the utilization of timber resources but also for regulating and monitoring all activities. The highest economic benefit derived from CBF by timber dealers is timber extraction, which also leads to income generation and job creation for the rural dwellers. Plantation establishment ranked topmost among the CBF activities involved in by timber dealers; however, timber dealers are not involved in forest protection and the decision-making process. Introduction of CBF in the selected communities of the state has contributed to community development, improvement in the timber business, and cordial working relationships among the forestry officials, timber dealers, and rural residents. For effective participation in CBF, however, empowerment of stakeholders in the decision-making process has been identified as crucial.

Valuation of ecotourism potential of Olumo Rock, Abeokuta, Nigeria, using the travel-cost model approach. Akintunde, O., Olakunle, S. (*Federal University of Agriculture, Abeokuta, Nigeria; akol_ak@yahoo.com; olakunlesegun60@yahoo.com*).

This paper investigated the monetary value placed on ecotourism potential of Olumo Rock, Abeokuta, Nigeria, as perceived by visiting tourists. Open-ended questionnaires in a non-probability snowballing method were used to capture primary data from visiting tourists on ecotourism values of the resort. Descriptive statistics, multiple regression analysis, and the travel-cost model approach were used to analyze the data. Results indicated that most visitors were male (54%) and residents of Lagos State, Nigeria (60%). Thirty-eight percent of visitors were students, and 44% had some college education. Other results were as follows: 72% were visiting for recreational purposes, 26% encountered hill climbing as a problem, and 74% were fairly satisfied with the staff-visitor relationship and the site resources and facilities. Most (68%) came in their private vehicles. The vast majority (90%) indicated they wanted to return, but most (66%) were not saving for such a trip (66%). The travel cost analysis showed that visitors using private transportation incurred more expenses than those using public transport. The reduced model regression revealed that variables such as income, distance to site, and travel cost significantly influenced the visitation rate to Olumo Rock. Effective management of park resources and facilities and improvement in staff benefits were some of the respondents' recommendations.

Beyond individual plant yield: integrating diverse socio-environmental factors into estimates of commercial production of an Amazonian non-timber forest product. Alechandre, A., Melo, T. (*Federal University of Acre, Brazil; andreaalechandre@hotmail.com; tadeu.melo12@gmail.com*), Fonseca, F., Munaretti, A., Evangelista, J., Wadt, L.O. (*EMBRAPA Acre, Brazil; fernanda.fonseca@embrapa.br; alisson@florestal.eng.br; joziane.gestorambiental@gmail.com; lucia.wadt@embrapa.br*).

Non-timber forest product estimates are one of the biggest challenges for sustainable forest management by Amazonian smallholders. Often, producers generate optimistic overestimates, which can have negative ramifications for buyers, who need to reliably satisfy market demand. Although *Euterpe precatoria* is an abundant, fruit-producing Western Amazonian palm with an established market, consistent production by smallholders is hindered by several factors: thin stems which must be skillfully climbed to reach crown fruits, rapid fruit perishability (after only about 48 hours without refrigeration), and often difficult access to sufficient fruit quantities. The authors analyzed production from one landholding, mapping 12 ha of 50-m riverine transects. Seventy percent of 772 individuals were scalable, yielding an estimated 7.6 tons of fruit based on 14 kg of fruit per plant. Nonetheless, poor fruit formation and bird predation diminished production to such low levels that the harvester did not enter the market. The authors conclude that smallholder productivity estimates must go beyond individual plant yield estimates to include wildlife interactions, harvest and transportation logistics, sales price, labor availability, and social organization to potentially group smallholder sales. Perhaps consideration of these multiple factors for production estimates would increase the likelihood of smallholder business success.

Stakeholders' perception as support for forest landscape planning in Ciliwung watershed, Indonesia. Alviya Abdul Manap, I., Suryandari, E., Muttaqien, Z., Maryani, R. (*Forest Research and Development Agency, Indonesia; iisalviya@yahoo.com; elvida_ys@yahoo.com; zahrul-m@indo.net.id; retnomaryani@hotmail.com*).

Forests play a vital role for people in both rural and urban communities. An important aspect of forest management is the addressing of perceptions of forest users towards forest practices. This paper aimed to illustrate stakeholders' perceptions about criteria for forest management and about current biophysical, socioeconomic, and institutional aspects of forest landscape management. Information was gathered through a survey instrument designed to identify the preferences, perceptions, and expectations of people with an interest in the general impact of ongoing management of Ciliwung watershed in Indonesia. Data were analyzed descriptively and quantitatively using a Likert scale. Respondents in government and upstream communities indicated the institutional aspect was the most important factor in forest landscape management of Ciliwung watershed. In contrast, communities of the middle watershed indicated biophysical and socioeconomic factors were the most important. Regarding biophysical aspects, respondents indicated reforestation and conservation of soil and water in the upper watershed were the most important programs to undertake. In socioeconomic aspects, compensation mechanisms from downstream communities

to upstream communities are needed in order to increase upstream community welfare because of the low incomes of upstream residents. In institutional aspects, stakeholders say there is still a need to increase interaction and coordination among stakeholders, law enforcement, and forestry managers to support the preservation of forest in the upstream watershed.

Assessing cultural ecosystem services and their association with other ecosystem services in a research forest in the western Cascade Mountains of Washington, USA. Ameyaw, L., Weir, E., Petri, D., Ettl, G. (*University of Washington, USA; lkameyaw@uw.edu; ellenf3@uw.edu; dianap@uw.edu, ettl@uw.edu*).

Field observations, interviews, and questionnaires were used to document visitor use at the 1 740-ha University of Washington (USA) research forest. The visitor use data were combined with maps of forest stand age, geologic features and waterways, and scenic vistas to describe the relative importance of provisioning and biotic ecosystem services to cultural ecosystem services (i.e., visitation for recreation and solitude). Visitors entered the forest primarily on foot or by horseback with most access happening along two state highways that border the forest. Most of the visitors lived within 20 miles of the forest entrance and had visited the forest more than 10 times in their lives. Analysis showed that visitor activity was mostly dog walking, horseback riding, observing/photography, or hiking/walking, or a combination thereof. Visitors most frequently visited one of the following locations: old-growth forest reserve, confluence of a medium and large river, a waterfall, several isolated trails, and the gravel road network. An analysis of visitor use data with other landscape and forest stand (age, tree size, reserves vs. production forests) attributes was used to examine the relative importance of forest management to the cultural ecosystem services provided by a working forest.

Amenity forestry and environmental sustainability: the example of Calabar Botanic Garden, Cross River State, Nigeria. Aya, F. (*University of Calabar, Nigeria; ayafelix@yahoo.co.uk*), Fidalgo Fonseca, T. (*University of Trás-os-Montes and Alto Douro, Portugal; tfonseca@utad.pt*).

This research focused on the importance of amenity forestry in environmental sustainability. The study site was Calabar Botanic Garden, which is located in the city center of Calabar (4°57′0″N, 8°19′0″E), the capital of Cross River State, Nigeria. This location offers a rare situation: a natural habitat-of-choice where birds and other wildlife live freely within a highly populated human environment. Facilities for recreation and special events are also in place. Inventory of all tree species and selected species of shrubs, herbs, grasses, and fauna was carried out. A total of 302 tree species were enumerated, representing 171 (57%) and 131 (43%) indigenous and exotic species, respectively. The garden has a total area of 34 835 m^2. Tree crown cover was 10 731 m^2, of which 9 374 m^2 (87%) was from indigenous trees and 1 357 m^2 (13%) from exotic trees. Total mean wood volume of trees was 253 m^2, to which indigenous trees contributed 238 m^2 (94%) and exotic trees 15 m^2 (6%). Total population density of tree species was 0.028 tree m^2, with indigenous and exotic species contributing 0.016 tree/m^2 and 0.012 tree/m^2, respectively. In conclusion, the greenbelt status of the garden offers tangible and intangible benefits comparable to those of a natural forest.

Preparing forestry students for the labour market outside targeted sectors. Barianti Ahlberg, D., Lewark, E. (*University of Freiburg, Germany, dbarianti@yahoo.com; siegfried.lewark@fobawi.uni-freiburg.de*).

More than one-third of graduates with a degree in forestry find jobs outside forestry, forest-based industry, or natural resource management, according to recent analyses in Germany. These employment results indicate that forestry programmes need to prepare their graduates for career choices outside the targeted sectors. There is, however, limited information available on forestry graduates' successful employment in non-forestry sectors. This paper reviewed relevant literature on the employability skills of forestry graduates, their employment situation, postgraduate placement trends, and the challenge and experiences of transition from higher education to work, along with employers' and recruiters' views on hiring and working with forestry graduates in non-forestry sectors. It also reviewed factors determining the employment of forestry graduates and graduates of higher education institutions in general. The relevance of the skills gained in these studies for the world of work as perceived by graduates, employers, and recruiters was also explored using a signaling model and human capital theory. Findings from this review may shed light on the design of curricula that aim to educate future forestry graduates to fulfill alternative roles in non-forestry sectors.

Updated identification and evaluation of species produced by the Barreirinha Municipal Garden nursery in Curitiba, Paraná, Brazil. Batista, D.B., Araújo, D., Viezzer, J. (*Federal University of Paraná, Brazil; dbiondi@ufpr.br; damarislevita11@yahoo.com.br; jeviezzer@yahoo.com.br*).

Plants produced in municipal nurseries supply urban forests and should be evaluated in the context of the urban population and local ecosystem. Origin of species (exotic or native), toxicity, and invasive features (as nationally or regionally invasive exotic species) are some aspects that should be considered. Plants from municipal nurseries are used mainly for ornamentation, urban forests, recovery of degraded lands, and environmental education. The objective of this study was to identify and evaluate tree species produced by the Barreirinha Municipal Garden nursery, in Curitiba, Parana, Brazil, from 2008 to 2013. Methods were based on previous research conducted in 2008 that used the following variables: scientific name, popular name, family, life form, toxicity, species origin, invasive features, and use. The number of species produced was reduced from 165 prior to 2008, to 138 species. Of these, 44% were new species. Among them, 22% are exotic, including an exotic invasive (*Schefflera actinophylla*) and one with toxic sap (*Aphelandra squarrosa*). The adoption of this form of evaluation is recommended to maintain an updated production record, which can help in establishing criteria for the production of more suitable species for urban forestry in Curitiba.

Project Floresta-Escola: an interaction between elementary school students and the forest. Batista, D.B., Soldera, C., Perego, D., Bouças, G.C., Wassem, G.F. (*Federal University of Paraná, Brazil; dbiondi@ufpr.br; carolsoldera54@gmail.com; dioney_perego@hotmail.com; gabriele_calle@gmail.com*), Francisco, R.A., Candido, S., Melnik, C.S, Tokarski, A.A.B., Viezzer, J., Martini, A.

Environmental education is an important tool for building values in people and aims at developing the relationship between human beings and the environment. To this end, the project "Floresta-Escola," begun at the Federal University of Paraná in Brazil in 2006, brings environmental education activities to students of public and private schools through an informal curriculum. Excursions are made to a fragment of the Araucaria forest in the city of Curitiba, Brazil. Inside this forest, students are taught about topics such as identification of local plant species, climate, water conservation, nutrient cycling, and interactions between the forest and its wildlife. At the end of each field trip, the students and visiting teachers receive booklets developed by the supervisors reinforcing the content presented during the excursion. Visitors evaluate the activities by completing surveys, which in turn are used to analyze and improve the learning experience. Weekly meetings are held with the supervisors to discuss experiences and suggestions for improvement. Since its inception, the project has reached 200 schools and more than 4 000 students, thereby promoting environmental education to students and enriching the related curriculum.

Participatory monitoring of non-timber forest products. What factors lead to cooperation? Brites, A., Morsello, C. (*University of São Paulo, Brazil; alicebrites@usp.br; alicebrites@gmail.com*).

The commercialization of non-timber forest products (NTFPs) has been promoted in communities inhabiting natural areas as an activity that promotes economic development with low environmental impacts. However, studies have shown that, frequently, there is a tradeoff between conservation and development objectives.To take into account these different objectives, it is suggested that these initiatives need to be monitored. Participatory monitoring has been widely discussed in the literature. For participatory monitoring to be successful, however, it is necessary to know if communities are willing to participate. But what leads an individual to engage in monitoring? Gathering knowledge about cooperative behavior from areas like social psychology and economics, the authors are attempting to identify the factors that can influence participation. The hypothesis is that subjective characteristics (e.g., perception of impacts) have a greater influence on the propensity to participate than do objective factors (e.g., gender). To test the hypothesis, a study was conducted in a Brazilian Amazon community that trades NTFPs. Three approaches were used: survey, focus group, and implementation of experimental monitoring. The results will improve understanding of the factors that promote or constrain participation and will allow creation of monitoring plans best suited to the context of each NTFP trade.

Community food forests in the United States: What environmental and social benefits do they provide? Who is using them and why? Bukowski, C., Munsell, J. (*Virginia Polytechnic Institute and State University, USA; cjbukows@vt.edu; jfmunsel@vt.edu*), Chamberlain, J. (*U.S. Forest Service, USA; jchamberlain@fs.fed.us*).

Community food forests are increasing in popularity across the United States. Although they have a long history in many countries, their use across U.S. landscapes constitutes a new frontier where agriculture and forestry combine via the science and practice of agroforestry to produce food, provide ecological services, and contribute to community development. Food forests represent an opportunity for expanding the use of agroforestry in the United States, ranging from individual landowners to whole communities. An increase in agroforestry across both rural and urban landscapes has important implications for the health and productivity of communities and ecosystems. This research will examine the environmental and social benefits that food forests provide. The development process, forest structure, and community characteristics of food forests in the United States will be examined. Stakeholder motives, preferences, and perspectives on the role of food forests are being studied, along with the processes used to design, establish, and manage them. Project objectives are to provide one of the first generalizable studies of community food forests in the United States and develop best practices at the outset of an emerging movement.

Comprehensive Curriculum Revision 101. Bullard, S., Coble, D., Coble, T., Darville, R., Rogers, L., Stephens Williams, P. (*Stephen F. Austin State University, USA; bullardsh@sfasu.edu; dcoble@sfasu.edu; tcoble@sfasu.edu; rdarville@sfasu.edu; rogersla@sfasu.edu; stephensp@sfasu.edu*).

In order to meet the needs of the changing profession of forestry, it is important for education programs to systematically review and revise their programs to reflect those needs. Curriculum review and revision is not for the meek, yet is absolutely necessary. In 2013 the Arthur Temple College of Forestry at Stephen F. Austin State University (ATCOFA, Texas, USA) completed a year-long study not only to obtain the best possible information for revision of its own curriculum, but also to help in development of a template that other forestry programs could use in their review processes. ATCOFA used a mixed method approach first grounded in the Pinchot Institute Report of 2001 and importance/performance methodology. Using surveys of alumni and focus groups of current and potential employers, ATCOFA was able to obtain a big picture of what the needs of its students may be over the next 20 years. This information was taken to the faculty for discussion and incorporation into the current and future curriculum. After completion of the curriculum revision, the research team revised the process and tools to produce a model for usage by other forestry programs. This presentation gives a brief overview of the process and the results.

Ecosystem services and human well-being in the Brazilian Amazon: contributions from a landscape analysis. Camilotti, V., Pinho, P., Escada, I. (*National Institute for Space Research (INPE), Brazil; vagner.camilotti@gmail.com; patricia.pinho@inpe.br; isabel@dpi.inpe.br*).

The Amazon rainforest is considered one of the most important ecological systems. It is responsible for the provision of crucial ecosystem services and goods with economic and social values essential for the maintenance and improvement of human well-being. This research investigates through landscape analysis how community households use some important forest resources (timber and non-timber forest products) and how these vary in a landscape gradient. By applying semi-structured questionnaires about the perception of several dimensions of well-being and the use of forest products, the authors were able to link these to a disturbance gradient in the study area located in the Midwest region of Pará State, Brazil. Results showed that forest products have low to high importance for household consumption and low value for income generation. Results also indicated that exploitation of the forest is generally carried out without any forest management. Well-being indicators differed greatly; health, education, and income showed the lowest values whereas others like security in the community and households' participation in

community decision-making varied from medium to high. These results were integrated into a landscape analysis in which relationships among landscape characteristics, human well-being, and the use and importance of forest resources could be observed.

Mapping boundaries of Community Conserved Areas: institutional and operational challenges. Chaliha, S., Ved, N. (*Foundation for Ecological Security, India; swatichaliha@gmail.com; nimesh.ved@gmail.com*).

Defining spatial boundaries of Community Conserved Areas (CCAs) is important for consistent understanding among stakeholders and for laying down operational rules. In Nagaland, India, assigning natural features as boundaries has been the customary practice and cadastral maps do not exist. Defining CCA boundaries there is crucial in the current context of development and conservation. The process of mapping boundaries raised many questions. While in one CCA of Nagaland, the authors, with villager assistance, mapped the boundary by using GIS data and walking with GPS receivers. In another CCA, efforts involved teaching selected villagers to use GPS for mapping. In the first case, an organized arrangement between the traditional local leadership and the institution managing the CCA aided the mapping process. In the second case, the terrain was difficult and coordination between different governing institutions was weak. Questions arose as to whether it is worth the effort and whether boundaries recollected from customary practice would suffice. Villagers expressed confusion about many topics, ranging from whether they would lose land to whether a boundary could be changed at a later stage. Because these CCAs differed in context, geography, and institutional arrangements, the authors' work with them helped demonstrate that multiple participatory approaches for mapping could be effective and aid management decisions for different kinds of CCAs.

Integrating forestry capstone curriculums: preparing today's students to be tomorrow's forest managers through education in sustainability and certification. Cushing, T. (*Clemson University, USA; tcushin@clemson.edu*).

This paper presents an innovative curriculum designed by Clemson University (USA) with funding from the American Forest Foundation. The curriculum is designed to provide faculty members with the tools needed to teach an integrated capstone course that highlights the importance of understanding the objectives of different ownership groups. The curriculum includes six sets of PowerPoints with lecture notes, questions for instructor use, and a Web site with discussion board. The curriculum was designed to be portable throughout the United States and available to anyone. Students will benefit from this integrated approach as not all course instructors have been able to work with a diversity of owners. The curriculum includes information on public ownership, investment, industry, and family owners. The paper will discuss the need, framework, content, and results of evaluations from faculty using the curriculum.

Distribution of potential REDD+ benefits from agricultural lands in forests and forest-savanna transition zones of Ghana. Damnyag, L., Oduro, K., Foli, E. (*Forestry Research Institute of Ghana, Ghana; lawdam@yahoo.com; kwameoduro@gmail.com; efoli@hotmail.com*).

REDD+ is designed to create incentives for the reduction of emissions from deforestation and forest degradation, carbon stock enhancement, and conservation and sustainable management of forests in developing countries. Emphasis on addressing issues of REDD+-related benefit distribution has mostly been at the international and national levels, with very limited analysis at the lowest tier of the administrative hierarchy, namely, the village, community, or farm. Ghana has had no experience with implementation of REDD+ pilot projects. Therefore, how benefits under REDD+ implementation should be shared between stakeholders, particularly at the forest and farmland level where emissions reduction activities take place, is yet to be fully understood. This paper presents an analysis of how potential REDD+ benefits could be distributed among beneficiaries at the community/forest level to ensure effectiveness, efficiency, and equity in REDD+ implementation. Data were collected from 236 farmers in two communities each from three administrative districts in Ghana using individual interviews. The paper presents models for potential REDD+ benefit distribution at the community level, and to individual farmers to secure legitimacy and support for national REDD+ strategy design and implementation. Community preferences would not be static but are subject to changes, particularly as REDD+ activities proceed.

Dietary pattern of indigenous people, local people, and immigrants in the vicinity of Harapan Rainforest, Indonesia. David, W. (*Bakrie University, Indonesia; wahyudi.david@bakrie.ac.id*), Widianingsih, N. (*University of Copenhagen, Denmark; nayu@foi.ku.dk*), Ardiansyah, A. (*Bakrie University, Indonesia; ardiansyah@bakrie.ac.id*), Ploeger, A. (*University of Kassel, Germany; a.ploeger@uni-kassel.de*).

Dietary patterns of societies depend on their household income, geographic location, and culture. According to Indonesian regulation No. 18/2012 and Presidential Regulation No. 22/2009, Indonesia Food Security Policy is based on optimization of local resources for acceleration of food consumption. Local food security can be achieved if the carrying capacity of the environment is suitable to meet local needs. Harapan Rainforest (HRF) is a forest restoration area in accordance with regulation SK 327/Menhut-II/2010 and SK 293/Menhut-II/2007 and is located in Jambi and South Sumatra. Three different ethnic groups (indigenous, local, and immigrant) have been using the resources within 20% of the area, which is tropical lowland rain forest. Communities residing in or near restoration areas generally have fewer financial assets but are rich in natural resources. Thus, a thorough review of the daily food intake type from forest resources is needed for each ethnic group in the context of local food security to avoid conflicts between restoration and community needs in and near HRF. This research will be carried out from November 2013 to February 2014 using the survey method in three villages located next to HRF.

The local particularity of the livelihoods of taungya participants in the teak plantations in the Bago Mountains, Myanmar. Ei, Takeda, S. (*Kyoto University, Japan; ei641986@gmail.com; takeda@asafas.kyoto-u.ac.jp*).

Since the 19th century, teak (*Tectona grandis* L.) plantations have been established in the Bago Mountains of Myanmar using the taungya system. This system combines plantation operations with intercropping and is carried out by local swiddeners, who practice a type of cultivation that is also known as "taungya". Nowadays, taungya participants still play an important role in teak

plantation programs because of the cost-effectiveness of the taungya system, which was adopted for Myanmar forestry centuries ago. However, taungya participants in the teak plantations have gradually formed communities that are engaged in various kinds of taungya practices for their livelihoods, especially after the recent expansion in private plantations. To explore the interactions between teak plantations and the local communities, a study was conducted at three different locations in the Bago mountain range, giving preference to both those areas which, historically, have had teak plantations and those which are currently most densely planted with teak. Using questionnaires and semi-structured interviews, the household surveys sought information on crop production and consumption, plantation work and income, the experience of the taungya participants, and other matters at each location. The different ways in which people participated in the taungya system were clearly observed at each site. These differences among the communities and their concerns with the teak plantations are discussed in this study.

Promoting co-benefits of ecotourism as a complementary strategy for sustainable management of Gunung Halimun Salak National Park. Ekayani, M., Nuva, N., Nurrochmat, D. (*Bogor Agricultural University, Indonesia; metieka@yahoo.com*, *nuvamaresfin@yahoo.com; dnrochmat@yahoo.com*).

The richness of Indonesia rain forest biodiversity not only provides invaluable ecological functions but also is very important to support economic development and local communities. Ecosystem services contributed up to 21% of Indonesia's GDP, including 75% of income for the rural poor. Despite this importance, Indonesia's biodiversity is under threat from habitat degradation, deforestation, climate change, unsustainable forest management practices, and overexploitation of natural resources. A large number of endemic plant species are endangered, suffering from intense deforestation and other destruction. Therefore, conservation of forest plants is vital to Indonesia not only biologically, but also economically. The Gunung Halimun Salak (TGHS) National Park has been playing a pivotal role in conserving genetic resources and the habitat of native plants. In addition to its role as a conservation forest, the park has provided several co-benefits such as wonderful landscapes and ecotourism attractions. The park is an ideal ecotourist destination because it meets the three most important criteria for ecotourism: an interesting place for nature tourism; supporting environmental education; and improving the regional economy as well as social well-being. This study confirmed that the co-benefits of ecotourism play an important role in supporting sustainable TGHS national park management.

The role of mangrove forests in sustaining household livelihoods in the Niger Delta, Nigeria. Eleanya, K. (*Federal University of Ducima, Nigeria; kele802001@yahoo.com*), Agbeja, B. (*University of Ibadan, Nigeria; olasinaa@yahoo.com*).

Mangrove forests are increasingly recognized as crucial ecosystems in sustaining the livelihoods of households that dwell in and around them. This study provided a critical assessment of household livelihood opportunities derivable from the mangrove forest in Akassa in the Niger Delta. Non-compliance with the Akassa Forest Policy has led to continued deforestation of the vast mangrove forest resources, thereby threatening the livelihoods of a growing rural population in the Niger Delta wetland. Structured questionnaires were used to gather information from the households, and participatory rural appraisal techniques were also adopted to gather relevant data. Measures of economic evaluation and analysis of variance were some methods used to analyze data. Willingness to participate in Akassa Forest Policy was dependent on location of households. The three highest average monthly income values for livelihoods in naira (₦) were speedboat driving (₦38 952), canoe carving (₦36 824), and logging/chain saw rental (₦31 075). In the face of the current unsustainable trend of mangrove forest exploitation, approaches for adopting people-centerd and community-driven forest policy are offered for attaining sustainable livelihoods.

Development of a trail auditing tool for trails at the wildland-urban interface. Gatti, E. (*University of Utah, USA; elise.gatti@utah.edu*).

This poster presentation describes a trail auditing tool devised to assess trails at the wildland-urban interface, including trails that originate within or at the periphery of urbanized areas and extend into more natural areas. The tool was developed using a segment of the popular Bonneville Shoreline Trail in Salt Lake City, Utah, USA. A new trail assessment tool is necessary because the motivations and preferences of trail users in the wildland-urban interface differ from users of urban-only trails or trails within designated wilderness. Specifically, these users are in search of naturalized conditions that provide a context for physical activity close to home or work. A review of existing approaches to evaluating urban and wilderness trails and a pilot study was used to inform the development of this new trail auditing tool, which uses GPS and GIS to document trail conditions and experiential characteristics. This tool will be of interest to trail and forestry professionals who must address the tensions inherent in heavily used and accessible trails in the wildland-urban interface, mainly by balancing the demands of urban development with retaining a natural setting.

Multi-stakeholder approach for managing conflicts and developing shared vision on community-based forest management in Nepal. Ghimire, M. (*Ministry of Forests and Soil Conservation, Nepal; ghimire.madhu@gmail.com*).

The forests of Nepal significantly influence the people's well-being directly and indirectly by providing environmental services. Nepal has pioneered community-based forest management (CBFM), and its different models are promoted and strengthened to sustainably manage the forests and address community needs and aspirations. This study assessed and compared the models on conceptual, legal, institutional, and operational aspects, and on their acceptance and degree of complexity in implementation. The study also explored possible strategic measures for developing shared vision and minimizing conflicts using a multi-stakeholder approach. This study was based on primary data (field visits and expert consultations) and a literature review. Results show that these models have many similarities, especially regarding community empowerment and sustainable management, but differ on community engagement, governance, and ownership arrangements. Performance of each model is governed by local conditions of landscapes, resource distribution, community participation, and degree of conflicts. A gap exists between policy and practical applications of these models, and there is limited evidence for making valid comparisons. However, the recently promoted multi-stakeholder approach has been effective in managing conflicts by promoting constructive ideas through concurrent existence of various approaches working towards a shared vision.

The effect of the deforestation rate on human activities in Central Africa: CoForTips project. Gillet, P. (*University de Liège-Gembloux Agro-Bio Tech, Belgium; pgillet@ulg.ac.be*), Feintrenie, L. (*CIRAD, Cameroon; laurene.feintrenie@cirad.fr*), Vermeulen, C. (*University de Liège-Gembloux Agro-Bio Tech, Belgium; cvermeulen@ulg.ac.be*).

The objectives of this study were to evaluate the impact of deforestation on human activities in Central Africa and to analyze changes in these activities. The research was based on the use of an interactive model and on surveys held in villages located at three different stages on Mather's deforestation curve (Mather, 1992). This curve shows the relationship between forest cover and population density. The three stages in this study were: (1) large proportion of intact forest cover, (2) forest partially degraded and under pressure of conversion to other land uses, and (3) smaller areas of degraded forest with a trend of deforested land being planted with useful trees. The three study sites represent three different Central African socio-ecosystems. The surveys provided information on the evolution of schooling, diet, the percentage of the family budget required for food, productivity of agriculture, change in land tenure rules, and change in the use of non-timber forest products. An interactive model was also used as a tool for participatory mapping in order to describe villagers' perception of space and time. Results of this study focus on socioeconomic data such as a description of life conditions and enhancement of resources in the three villages.

Bird song diversity influences young people's appreciation of urban landscapes. Hedblom, J. (*Swedish University of Agricultural Sciences, Sweden; marcus.hedblom@slu.se*), Heyman, E. (*COWI, Sweden; erhe@cowi.se*), Antonsson, H., Gunnarsson, B. (*University of Gothenburg, Sweden; henrik.antonsson@bioenv.gu.se; bengt.gunnarsson@bioenv.gu.se*).

Increased losses of green areas in cities reduce people's experience of flora and fauna. Earlier studies have shown that biodiversity has benefits for urban inhabitants, but the influence of animal sounds on people's experience of green space is poorly known. A sample of young urban people (N=227) rated their reactions—positive or negative— to three bird song combinations (house sparrow (*Passer domesticus*), willow warbler (*Phylloscopus trochilus*), and seven urban woodland species), three urban settings (residential areas with varying amount of greenery), and nine combinations of song and setting. Bird song was generally considered positive and singing by several species was more highly rated than singing by a single species. On average, urban settings combined with bird song were more highly appreciated than the settings alone and even more so where there was singing by several species rather than just one. The authors conclude that our data support the idea that bird song contributes to positive values associated with urban green space. Urban planners should consider preserving a variety of habitats in cities for hosting a diversity of birds and thereby boost both conservation of songbird diversity and recreational experiences for urban people.

Creative approaches to joint urban forest management: a case study of several urban parks in Guiyang, China. Hu, X. (*Seoul National University, Republic of Korea; huxiaohuan1989@gmail.com*).

Urban parks can provide citizens with diverse ecosystem services that are essential to the urban public welfare. On the one hand, local governments in China with limited budgets feel thwarted in their efforts to build more urban parks for the public. On the other hand, governments are criticized for selling public land, which is usually surrounded by beautiful natural landscapes, to real estate developers in order to enhance government income. Such sales remove the right of public access to those lands for citizens' recreational. This study is based on field research and analysis of stakeholders regarding several newly built urban parks located in Guiyang, a southern China city. It explored a variety of examples that make joint management between governments and real estate developers possible. In practice, governments authorized the developers to build residential buildings at the edge of natural landscape areas under the stipulation that the developers must invest in and improve those areas by creating parks that are accessible and open to the public and offer amenities. Furthermore, the developers are responsible for paying for the future daily maintenance of the urban parks. Results of this survey give fresh insights for future urban planning and development.

Study on forestry and related students' cognition, attitude, and behavior toward biodiversity in Taiwan. Huang, M. (*National Chiayi University, China-Taipei; myhuang@mail.ncyu.edu.tw*); Chiang, A. (*National Chengchi University, China-Taipei; eliot.chiang@gmail.com*), Fong, C. (*National Chiayi University, China-Taipei; s1000090@mail.ncyu.edu.tw*).

This study investigated the cognition, attitude, and behavior of students in forestry and related disciplines toward biodiversity and examined how students' different background affected their cognition, attitude, and behavior toward biodiversity. Furthermore, the study explored relations among cognition, attitude, and behavior toward biodiversity. A questionnaire was administered to undergraduate students in forestry and related departments in Taiwan. There were 630 valid samples, for a response rate of about 87%. Key findings follow. First, regarding background, there were significant effects of gender and residence before entering universities on attitude toward biodiversity. Participating in biodiversity courses, field trips, or camps had a significant influence on attitude and behavior toward biodiversity. Second, there was positive significant correlation between (1) cognition and attitude toward biodiversity and (2) attitude and behavior toward biodiversity. Results and suggestions from this study would provide useful information for policy-makers in the educational agencies of the government when they establish and implement policies about environmental education related to biodiversity.

The value of graduate undergraduate mentorship programs in academia. Hulbert, J. (*Oregon State University, USA; joseph.hulbert@oregonstate.edu*).

Graduate students in the College of Forestry at Oregon State University (USA) initiated a Graduate Undergraduate Mentorship Program (Forest GUMP) in spring 2013. In the first term, 20 undergraduate students were paired with graduate students. At the end of the term, a survey of the participants was conducted and analyzed. The questionnaire focused on program values and improvements. Sixteen graduate students and 12 undergraduate students participated in the survey. Results from the analysis suggest graduate students are capable of contributing unique values compared to other individuals in academia. Of the surveyed graduate student mentors, 94% agreed participation gave them new insight, or experience, that will be helpful in future mentorship roles. Two-thirds of undergraduate survey participants indicated that after participating, they were more interested in graduate school, 75% indicated they would think more carefully about future goals, and 83% claimed they were more prepared to reach

their future goals. All responding graduate and undergraduate students indicated they would participate next term. Graduate undergraduate mentorship programs can be valuable components of academia and the organizers of Forest GUMP have already spoken with three other Oregon State University graduate student groups about starting similar programs.

Higher education and capacity development for sustainability and clean technologies: experiences from Mozambique. Husgafvel, R., Martikka, M. (*Aalto University, Finland; roope.husgafvel@aalto.fi; mikko.martikka@aalto.fi*).

Higher education needs to address the existing and emerging sustainability challenges in the forest sector and in bioproducts technology through the introduction and application of sustainability and clean technologies. Therefore, this study presents experiences from a collaborative project between two universities from Mozambique and Finland. The two universities aimed at (1) developing a specific study module with associated curriculum to offer expert training on sustainability and clean technologies and (2) developing Mozambican capacity to provide services for and to establish strong links with industry, national sustainable development efforts and initiatives, and other higher education institutions. The project activities presented encompass study module development, workshops, networking, and review of potential ways to bridge the gap between higher education for sustainability and addressing the main sustainability challenges within both industry and national sustainable development efforts. Lessons learned and recommendations can be applied to similar development efforts in any country or higher education institution. There are many potential benefits associated with incorporating sustainability and clean technology aspects into forestry education.

Tropical Hardwood Tree Improvement and Regeneration Center: strategies for creating a new collaborative research and extension partnership. Inman-Narahari, F. (*University of Hawaii, USA; finman@hawaii.edu*), Constantinides, M. (*Natural Resources Conservation Service, USA; michael.constantinides@hi.usda.gov*), Dudley, N. (*Hawaii Agriculture Research Center, USA; ndudley@harc-hspa.com*), Friday, J. (*University of Hawaii, USA; jbfriday@hawaii.edu*), Giardina, C. (*U.S. Forest Service, USA; cgiardina@fs.fed.us*), Imoto, R., Koch, N., Litton, C., Masuda, R., Michler, C., Robinson, M.

The Tropical Hardwood Tree Improvement and Regeneration Center (TropHTIRC.org) is the first tree improvement research and extension center for tropical hardwoods in the United States. Its mission is to advance the science of tropical hardwood tree improvement, utilization, conservation genetics, and reforestation. TropHTIRC profits from a unique partnership between industry, university, private, state, and federal entities including the U.S. Forest Service, the University of Hawaii, and Purdue University. The strategy to build the center is to create a successful program with one species, then expand to other species. The initial focal species is *Acacia koa* (koa), Hawaii's premier timber tree. Koa is a fast-growing species that produces high value lumber, improves endangered species habitat, and is a cultural icon. Through traditional breeding for increased disease resistance, growth, form, and wood quality, the center is developing improved trees to increase forest productivity and the economic value of reforestation programs. Current activities include establishing seed orchards to provide improved seed for large-scale reforestation of degraded lands, developing systems for nursery production and plantation establishment, and conducting research on ecological tolerances and disease management. The vision of TropHTIRC is to become the internationally recognized leader in sustainable production, protection, and utilization of tropical hardwoods.

Present situation of forest education, including forestry, environmental studies, and outdoor activities, in Japan. Inoue, M., Oishi, Y. (*Forestry and Forest Products Research Institute, Japan; imariko@ffpri.affrc.go.jp; oishi@ffpri.affrc.go.jp*).

Activities related to forest education have been widely carried out in Japan. Purposes of these activities include education about forest environments, learning about trees, environmental studies and education on sustainable development, and outdoor education. Moreover, classes related to forests and forestry have been taught in universities and vocational high schools for human resource training. In order to gain a comprehensive understanding of these various types of forest-related education, the content and purposes of the programs were classified based on analysis of literature, and then present situation of forest education was examined. Results indicate that forest education was offered as school education, vocational education, or training such as on-the-job training and lifelong education. Contents of forest education can be classified into four categories: forest resources, natural environment, nature experiences, and regional culture. The various purposes of forest education were summarized as "education through direct experience in forests for human resources who know regional forests as a natural environment and trees as circulation resources, who have acquired skill and awareness of forests, and who will support and promote a culture which establishes symbiosis with nature and a sustainable society."

Participatory forestry and rural development: sharable lessons for better management across South Asia. Islam, K. (*Bangladesh Agricultural University, Bangladesh & Kyushu University, Japan; kamrulbau@gmail.com*), Mallik, R. (*Nabakrushna Choudhury Centre for Development Studies, India; rmallik2004@yahoo.co.in*), Fujiwara, T., Sato, N. (*Kyushu University, Japan; takaf217@gmail.com; sato.noriko.842@m.kyushu-u.ac.jp*).

Participatory Forestry has emerged as a key approach to forest management in many Asian countries over the last few decades. This study looked at the foremost enabling factors as well as main constraints of PF towards rural development in South Asia. The study was based on case studies conducted in a Social Forest Management (SFM) site in Bangladesh and Community and Joint Forest Management (CFM, JFM) sites in India. Results revealed that SFM and JFM have been implemented as an extension of state control, rather than as a move towards real democracy. CFM, on the other hand, was initiated by the local community. However, every management system has some degree of success in addressing rural development issues, such as equity, participation of women, formation of local committees, benefit sharing, and improvements in overall livelihood. SFM and JFM have suffered from a rigid framework, whereas CFM has its own effective rules and management systems that bring local people to the center of planning. But CFM lacks government support services. Therefore, it is essential to fill the gap between policy and implementation, and the key issue is to adopt CFM approaches with appropriate government supports in order to enhance rural development in this region.

Prospects for strengthening social forestry in the coastal areas through introducing mangrove species at Shyamnagar upazila in Satkhira district, Bangladesh. Islam, M. (*University of Queensland, Australia; wasiulislam7@yahoo.com*), Baishnab, S. (*Khulna University, Bangladesh; ram080508@gmail.com*), Sadath, M. (*Khulna University, Bangladesh & Georg August University, Germany; mnsadath@yahoo.com*).

Social forestry through introducing mangrove species is becoming an increasingly important component of the environment and economy of Bangladesh. This study aimed to analyze how social forestry implemented by planting mangrove species affected the local people of Shyamnagar upazila in Satkhira district, in terms of socio-cultural, economic, environmental, and institutional impacts. This area has potential for mangrove social forestry because of its proximity to the coast. The field survey was conducted in 2012 using the purposive sampling method to collect data on the perceptions of the local residents and officials (forest department and NGOs). The results showed that respondents strongly agreed with the idea that the practice of mangrove social forestry provided many economic, environmental, and sociocultural benefits to the local people. It was also found that such forestry practice at Shyamnagar had high potential to generate income, help to protect the coastal land, build environmental awareness within local communities, conserve natural resources, improve the standard of living, and provide other benefits. The findings of this study may be helpful in developing a strategic management plan for mangrove social forestry at Shyamnagar upazila for the betterment of the local community as well as the environment.

Multi-level policy dialogues and actions for REDD+ social safeguards: observations from a global comparative study on REDD+. Jagger, P. (*University of North Carolina, USA; pjagger@unc.edu*), Brockhaus, M. (*Center for International Forestry Research (CIFOR), Indonesia; m.brockhaus@cgiar.org*), Lawlor, K. (*University of North Carolina, USA; klawlor@email.unc.edu*), Duchelle, A. (*Center for International Forestry Research (CIFOR), Brazil; a.duchelle@cgiar.org*), Sunderlin, W. (*Center for International Forestry Research* (*CIFOR), Indonesia; w.sunderlin@cgiar.org*).

This study provides a multiscale institutional analysis of actions related to social safeguards and Reducing Emissions from Deforestation and Forest Degradation (REDD+). The authors analysed the institutionalization of international REDD+ social safeguards through the development of international, national, and sub-national policies and processes directly related to the development, implementation, and assessment of REDD+. Data from the Global Comparative Study on REDD+ (GCS-REDD+) by the Center for International Forestry Research (CIFOR) were used from three countries, Brazil, Indonesia, and Tanzania. While these countries' safeguard policies and actions respond in part to the same set of international guidance and incentives, their national, subnational, and local contexts differ in important ways. The authors identified lack of national awareness of REDD+ social safeguards, limited debate among key actors including civil society and government, differences in how sub-national governments have approached social safeguards, and the extent to which national and subnational dialogues facilitate or hinder the integration of measurement, reporting, and verification of social safeguards at the project level as key areas of institutional strengths or weaknesses. Findings suggest that systems of polycentric governance related to REDD+ are likely to foster meaningful institutionalization of REDD+ social safeguards, particularly when compared with donor-driven dialogues and processes.

A research and experimental center for technology transfer regarding drought, land degradation, and desertification. Jamsran, T. (*Mongolia; tsogtbaatarj@magicnet.mn*), Akhmadi, K., Nyamtseren, M. (Mongolian Academy of Sciences*, Mongolia; khaulenbek@yahoo.com; maaggi@yahoo.com*).

Drought, land degradation, and desertification (DLDD) are ecological problems threatening not only the drylands of Mongolia but also forest ecosystems. According to the latest assessment of drought phenomena across the country, almost one-third of the total territory is affected by moderate or severe drought conditions. The hotspots identified by long-term drought monitoring showed that the Central Mongolian transition zone of steppes and dry steppes are the most vulnerable to this disastrous process. Besides the drought assessment, the latest desertification assessment, conducted in 2010, concluded that almost 60% of the steppe region is desertified. In 2008, the first research and experimental center of its kind was established in Elsen Tasarkhai, in the Bulgan region of Mongolia. As a part of its operational program, several technologies have been tested as responses to different kinds of land degradation processes occurring in the region. According to a sociological survey of the local population, such demonstrations positively influence people's land use practices. The center makes it easy for local residents to obtain environmental information anytime and its training programs provide environmental education, thus supporting local initiatives in tackling DLDD-related processes.

Development of a tool for analysing forest owners' strategies to manage risks and adapt to climate change. Jönsson, A. (*Lund University, Department of Physical Geography and Ecosystem Science, Sweden; anna_maria.jonsson@nateko.lu.se*), André, K., Gerger Swartling, Å., Vulturius, G. *(Swedish Environment Institute; karin.andre@sei-international.org; asa.swartling@sei-international.org; gregor.vulturius@sei-international.org*).

Climate change is expected to lead to more climate extremes, which increase the risk of forest disturbances with negative impacts on timber production and biodiversity. Through active choices, many forest management decisions can be taken to reduce the risks. To obtain the best possible basis for decision-making, an active science-practice dialogue is needed on adaptation strategies, model uncertainties, and management of conflicting goals. This study aimed to develop and test a discussion-support tool for analysing forest owners' decision-making strategies regarding risks of climate change, extreme events, pest infestation, and preservation of biodiversity. Through science-stakeholder dialogues with Swedish non-industrial forest owners, potential synergies and conflicts between active, proactive, and reactive risk management strategies in relation to forestry objectives are elucidated. The research shows how forest owners relate to and motivate these strategies in dialogue with scientists. The authors conclude that it is necessary to consider all three types of strategies to achieve the goal of sustainable forestry capable of producing a diversity of ecosystem services.

Too safe to survive: going overboard on free and prior informed consent. Kant, P. (*Institute of Green Economy, India; promode.kant@gmail.com*), Wu, S. (*Chinese Academy of Forestry, China; shuirongwu@126.com*).

Deforestation and forest degradation often result from economic activities that provide sustenance to communities. Policies and programs aimed at reducing resulting emissions could, therefore, deepen poverty and have other unintended social consequences unless properly safeguarded. Free Prior Informed Consent (FPIC) is an important safeguard celebrated for its moral value in recognizing the claims of original people of a land. But morality-based actions suffer from an inherent defect that compels movement towards positions perceived to be even higher in morality even when these positions are against overall public interest and bring little benefit to the communities themselves. FPIC also has the potential of being misused by vested commercial interests by misleading the traditional indigenous institutions, or colluding with their unscrupulous leadership, into withholding consent. This potential for misuse is compounded by the fact that often the traditional institutions are not democratic, tend to exclude women from decision-making, and are reluctant to share opportunities and resources with exogenous groups in their geographical space even when legitimate. The authors analyze examples from Asia to present cautionary and implementable limits on FPIC that can serve to further both REDD+ and the interests of indigenous communities.

Willingness of local communities to participate in REDD+ activities: a case study in communities in forest and forest savanna transition zones in Ghana. Kofie, W., Damnyag, L., Foli, E. (*Forestry Research Institute of Ghana, Ghana; winniekofie@yahoo.com; lawdam@yahoo.com; efoli@hotmail.com*).

This study was carried out to determine the willingness of local communities to participate in REDD+ projects and to explore the preferred form of REDD+ benefits and their distribution. Questionnaires were administered, and a literature review was conducted. The vast majority of the respondents (99%) in the communities were willing to participate in REDD+ projects, with farmers, landowners, traditional rulers, and community and opinion leaders being identified as key beneficiaries. The preferred forms of benefit sharing identified were cash (62.7%), in-kind benefits (10.6%), and a combination of both (22.9%). Most of the respondents (96.1%) indicated that monetary incentives should be given directly to individual households/farmers, 1.7% said it should be given to the community, and 2.1% indicated that it should be given to both households and the community. The authors concluded that at the local level, where activities contribute to deforestation and forest degradation, forest stakeholders are willing to participate in activities that would reduce deforestation and forest degradation and contribute to the enhancement of forest carbon stocks provided they receive commensurate benefits.

Analysis of factors contributing to urban greenspace cooling island intensity in the summer. Kong, F., Yin, H. (*Nanjing University, China; Fanhuakong@163.com; qzyinhaiwei@163.com*).

In this paper, greenspace cooling island (GCI) intensity as a GCI characteristic was first defined, and then multiple linear regression models were established to explore the combined effects of related greenspace pattern and background environment variables on the intensity of GCIs in urban areas. GCI intensity was significantly correlated with the size of the cooling island and its mean temperature. Results indicate that a cooling island is the aggregated result of cooler pixels and such a cooling sink may create an area of lowest temperature in the cooling islands. Multiple linear regression analysis showed that cooling island intensity was affected by the area and spatial arrangement of forest vegetation, as well as by the composition of the cooling island and the adjacent environment. The analysis will help to manage and plan the spatial arrangements of greenspace in cities to mitigate the urban heat environment and help cities adapt to climate change.

Alaska Natives, local knowledge, and climate change. Kruger, L. (*U.S. Forest Service, USA; lindalaska2003@gmail.com*), Powell, J. (*University of Alaska, USA; jim23powell@gmail.com*).

Tlingit people have called Southeast Alaska (USA) home since "time immemorial." Over the years generations have observed—and experienced—a variety of environmental, social, economic, and cultural changes. The authors are interested in what changes they currently are experiencing and how they are responding to those changes. Understanding how they perceive and experience change, how changes have influenced their lives and livelihoods, and how they respond to change may help us better understand, prepare for, and help other local residents prepare for climate change. This study employed in-person conversations with individuals, couples, and small groups in three rural communities in Southeast Alaska. Conversations were recorded and videotaped with permission. Conversations were transcribed and analyzed, and themes were extracted. Findings provide insight into plant and animal species that are culturally important, observed changes ranging from individual species to weather patterns, and insight into how people have responded to change in their past and current adaptation activities. The presentation will include quotations from the participants and a video clip of them speaking in their own words about these topics.

Environmental and economic impact of mangrove deforestation – case study of Vadamaradchy East, Sri Lanka. Kumarasamy, S. (*Norwegian University of Science and Technology, Norway; sasi451@yahoo.com*).

This study was conducted in Vadamarachchi-East in Sri Lanka over 2 months in 2011. Factors contributing to mangrove deforestation within the study area, and resultant impacts from deforestation, were examined. The study found that the main factors that have contributed to deforestation are: long civil wars in the region; poverty, which pushed people to clear the forest to earn income through the sale of firewood and timber; industrial development; increasing demand for farm and settlement land; limited knowledge within the local community; weak government policies and implementation strategies; and natural disasters, especially destruction by the 2004 tsunami. Environmental and economic impacts included loss of income sources, loss of biodiversity, climate change, desertification, conflicts in the use of forest products, and loss of land productivity because of reduced fertility caused by soil erosion. However, strategies have been put in place by the government to ensure the sustainable use of mangrove forest products, though these have not proved successful in reducing deforestation. Recommendations were made to the government and other stakeholders to work together to ensure sustainable use of natural resources, for example by implementing laws and regulations aimed at controlling deforestation.

Addressing climate change adaptation and mitigation through community-based forest management in Nepal. Lamsal, R. (*Ministry of Forests and Soil Conservation, Nepal; ramplamsal@gmail.com*), Kanel, K. (*Resource Identification and Management Society, Nepal; keshavkanel@gmail.com*).

Adaptation and mitigation can complement each other and together can significantly reduce the consequences of anthropogenic climate change. Community Forests (CF) have potential not only at the frontline in mitigation but also in increasing resilience through increased adaptation to major impacts of climate change. Based on case studies using participatory rural appraisal (PRA) methodologies in three CF sites of the Terai Arc Landscape area of Nepal, this study explored the role of CFs in contributing to mitigation and adaptation goals and provides insights into how and why adaptation considerations can be integrated within forest-based mitigation efforts. The study reveals that CF has the potential not only to protect land and people from some of the harmful effects of climate change but also supports community resilience, thus responding to multiple needs. Until recently, adaptation and mitigation have often been considered separately in climate change science, policy, and implementation. The cases demonstrate a strong adaptation-mitigation nexus. Although the contributions of CF to mitigation are well recognized, adaptation has received less attention at national and international levels until now. Therefore, it is imperative for the two actions to be integrated. Finally, recommendations are made on how to address these issues and future strategic considerations.

Ensuring social safeguards: forest use rights of local communities and participatory process of Lombok KPH REDD+ feasibility study in Indonesia. Latifah Endang Sunarya, S., Afifi, M. (*University of Mataram, Indonesia; slatifa23@yahoo.com; mansurafifi@yahoo.de*), Kim, I. (*University of British Columbia, Canada; inae.kim@alumni.ubc.ca*), Bae, J. (*Korea Forest Research Institute, Republic of Korea; forestry@forest.go.kr*), Fisher, L. (*University of Arizona, USA; lafisher@email.arizona.edu*), Kim, Y.

Ensuring indigenous populations' and local communities' rights, knowledge, and participation is an essential element of successful implementation of REDD+ projects. The authors present results from the recently completed Lombok KPH REDD+ feasibility study, in which mechanisms for ensuring social safeguards in REDD+ were explored. Participatory rural appraisal, focus group discussions, and household surveys in 14 administrative villages surrounding West Rinjani KPH were used. The research compares local people's rights, land tenure status, and forest governance institutions under different forest management systems including HKm (community forest) and KPH (forest management unit), and examines a gap between statutory and customary forest use rights. HKm gives rights to the local community to manage a state forest and has a unique mechanism for providing more secure tenure for local farmer groups in Indonesia. Four villages institutionalizing the HKm in forest management had higher land tenure security. Therefore, a few other villages intend to institutionalize HKm although the process takes 3–5 years. Meanwhile, KPH has apparently played an important role in developing formal and informal agreements with local communities to ensure greater social safeguards in managing forest resources.

Ecosystem services and protected areas: contribution of Pendjari National Park to Benin economy. Lawani, A. (*University of Kentucky, USA; abdelawani@gmail.com*).

Using the Pnedjari National Park (in Benin), this study provides additional arguments in favor of protected areas establishment. It shows that the benefits of protected areas go beyond their value to the environment and extend to the local, regional, and national levels. Ten activities have been identified around the Pendjari and the value of their contribution is $5,017,700 (0.07% of the GDP). Tourism, fishing, and game hunting contribute the most, but the profits generated from these activities are unequally distributed among the different players involved. More than 80% of the wealth generated by the tourism industry and almost 99% of revenue from game hunting do not benefit the local population. In contrast, traditional activities such as "Nere" (*Parkia biglobosa*) and Shea chains contribute equally to the livelihood of local residents, especially the poorest. Paradoxically, poaching activities, which violate conservation objectives, are found to be more profitable than beekeeping and organic farming. These findings support the hypothesis that we cannot expect active participation of local populations in protected areas conservation if they cannot reap more attractive and equitable benefits from them.

Social sciences in forestry curricula – experiences at the University of Freiburg, Germany, over 20 years. Lewark, E. (*University of Freiburg, Germany; siegfried.lewark@fobawi.uni-freiburg.de*).

Forestry curricula at universities traditionally include many disciplines/subjects, from natural sciences, technical sciences, and social sciences. Some universities have a traditional focus in subjects from natural sciences, others in technical sciences, with a guiding idea of preparing graduates for a position of a director of a forest district, very often in publicly owned forests. This paradigm was common in Central, Northern, and Eastern Europe. Since the introduction of new study programmes along with the Bologna Process, we have observed a diversification and new guiding ideas and approaches in Europe. In many cases new Master programmes centered around social science subjects have been started. The University of Freiburg, Germany, provides an example of curriculum revision. In 1995 a 5-year forest sciences programme was introduced giving equal time to subjects from natural sciences, technical sciences, and social sciences. When after 10 years Bachelor and Master programmes were introduced, this division of subjects was modified, and an international Master programme, "Master of Environmental Governance," was devoted entirely to social science disciplines. Some experiences with the background and experiences with these sample curricula will be related.

Research on present status of sustainable livelihood of workers' families in China's key state-owned forest region. Liang, Y., Zhu, H., Cao, Y. (*Northeast Forest University, China; 3259468@qq.com; 1512678643@qq.com; cyklk@163.com*).

China's key state-owned forest region refers to the Heilongjiang, Inner Mongolia, Jilin, Xingan, and Changbai Mountain forest sectors, also known as the northeast Inner Mongolia key state-owned forest region. In recent years, this forest region has experienced a transformation from timber production base to ecological functional area. Key state-owned forest household workers are a special group different from the peasants and urban workers. This study found that living conditions of the key state-owned forest region residents are better than those of farmers in the same area, but there is great disparity compared with urban residents. Forest resources were found to contribute little to household income, and there is still great potential for income generation from the forest. Findings revealed a heavy economic burden on these families. The population shrank noticeably in these regions. The authors' suggestions to policy-makers are as follows: (1) to invest more in the key state-owned forest region and to devote more attention to it, (2) to encourage residents to stay in these regions by some preferential policies, and (3) to make full use of the forest land resources, thereby increasing household income.

Enhancing community livelihoods through nature-based enterprises: the case of Matinyani women group, Kitui, Kenya. Lishindu Chiteva, R., Mayunzu, O., Wachira, N. (*Kenya Forestry Research Institute, Kenya; rchiteva@yahoo.com; omayunzu@gmail.com; normanwachira@yahoo.com*).

Nature-based enterprises (NBEs) are ventures that can be used to support biodiversity utilization, conservation, and equitable benefit sharing from derived resources. This paper highlights the potential of NBEs in enhancing community livelihoods in Kenya, with specific emphasis on Matinyani Enterprise in Kitui. In 2010, the 60-member group received both theoretical and hands-on training by Kenya Forestry Research Institute (KEFRI) in product development and setting up and registering an enterprise with the Ministry of Sports, Culture and Arts. The training included propagation, processing, and value addition of *Tamarindus indica* fruit for jam, juice, and wine. Frequent monitoring is done by KEFRI to ensure adherence to Kenya Bureau of Standards regulations and to maintain the quality of products. Evidence of the adoptability of the technologies and of improvements in group members' livelihood includes: increased awareness of sustainable utilization and conservation of indigenous fruit trees (IFTs), value-added indigenous fruit products being sold locally, and a small saving scheme "merry-go-round." A challenge remains with the adoptability of the propagation techniques because of the long time indigenous fruits take to mature. Therefore, there is a need to fast-track research in this area.

Páramos as changing ecosystems: a multi-temporal analysis of perceptions on the change of páramo areas in the delimitation process, Colombia. Lopez Gomez, C. (*Universidad Nacional de Colombia, Colombia; cplopezg@unal.edu.co*).

Multi-temporal analyses involving socioeconomic and cultural information were used to define the change of relationships between the population and protected high-altitude *páramo* areas as well as natural resources in the territory. The study aimed to identify the major changes in the areas in the course of the delimitation process in order to define the historical and cultural relationships between people and traditional or technologically advanced production systems and technologies that are being applied by the communities of the surrounding region within the jurisdiction of the local environmental Corporation of Corantioquia. It evaluated the impact of these production systems and technologies on the biodiversity and ecosystem services of *páramos*, and also defined sociocultural parameters that can be linked with physical and biotic criteria for the delimitation of *páramo* areas. The results highlighted the challenges and limitations of the participatory process and criteria for inclusion of the population in managing and transforming protected areas of high social value (e.g., the *páramos*) because of their importance for the provision of ecosystem services such as water. In addition, the current pressures on these ecosystems in the Department of Antioquia, Colombia, are evaluated, and the relationship between actors as the main axis for making decisions on protected areas, is analyzed.

Survival analysis in plantations of *Araucaria angustifolia* (Paraná pine) derived from seedlings and seeds. Maran, J. (*Federal University of Paraná, Brazil; jess.maran@gmail.com*), Rosot, M., Radomski, M. (*EMBRAPA, Brazil; augusta_rosot@hotmail.com; maria.radomski@embrapa.br*), Kellermann, B. (*Federal University of Paraná, Brazil kdbetina@hotmail.com*).

The forest type most characteristic of southern Brazil is the Araucaria forest, strongly marked by the presence of Paraná pine (*Araucaria angustifolia*). Overexploitation of this species reduced its range to 2% of its original area. A research project developed by EMBRAPA Forestry is concerned with the planting of *A. angustifolia* on small farms as a strategy for the conservation of the species and as an economical alternative to the producer. Therefore, an experiment was conducted to evaluate germination, survival, and predation rates of seeds and seedlings of *A. angustifolia*, analyzed as a completely randomized unbalanced factorial design with two factors (type of plantation: pure/mixed; raw material: seeds/seedlings), for a total of three treatments, with three replicates each. Fourteen months after planting only 17% of the seed spots contained live plants; 14% of planted seedlings survived. About 9% of the seeds did not germinate, and 60% were consumed by animals. Seedling mortality was 59% in the "pure" treatment and 80% in the mixed treatment. In the mixed treatment, seed losses due to fauna attack were lower (42%) compared to the "pure" treatment (69%); the opposite pattern was observed for seedlings.

A comparative analysis of global stakeholders' perceptions of the governance quality of the CDM and REDD+. Maraseni, T. (*University of Southern Queensland, Australia; tnmaraseni@hotmail.com*), Cadman, T. (*Griffith University, Australia; cadman@gu.edu.au*).

This paper provides a quantitative and qualitative analysis of global level stakeholders' perceptions regarding the governance of the clean development mechanism (CDM). The research conducted via an anonymous online survey, using a normative framework of principles, criteria, and indicators. It compares these findings with the results of a similar survey conducted by the authors on REDD+. Stakeholders from both the global North and the global South were asked to rate the quality of these mechanisms against 11 performance indicators, using a scale from "very low" to "very high" (1-5). Overall, the results from CDM stakeholders from both the global North and global South were very similar. The highest and lowest total scores were obtained from the institutional and social stakeholders, respectively. These results demonstrate that these two groups have considerable differences in perceptions. CDM failed in two indicators, "equality" and "resources," and passed marginally in all other nine indicators. The performance of REDD+ was much higher than CDM in all aspects of governance surveyed. The major differences were in "equality" and "problem solving." If the CDM is to be continued in the post-Kyoto period, some major systemic changes in governance are necessary, and some lessons can be learned from REDD+.

International Masters in Wood Energy: an EU project for developing higher education in the bioenergy sector. Marchi, E. (*University of Florence, Italy; enrico.marchi@unifi.it*), Tasanen, T. (*Seinäjoki University of Applied Sciences, Finland; Tapani.Tasanen@seamk.fi*), Jager, L. (*University of West Hungary, Hungary; jagerla@emk.nyme.hu*), Bonet, J. (*University of Lleida, Spain; jantonio.bonet@exchange.ctfc.es*), Picchi, G. (*National Research Council (CNR), Italy; picchi@ivalsa.cnr.it*), Navarro i Maroto, P., Smith, M.

The EU has set very challenging goals for the partial replacement of fossil fuels with renewable energy by 2020. In many EU countries forests are the main source of renewable energy and wood energy is booming all over the continent. Technologies for woody biomass production, transportation, and energy conversion are rapidly expanding both inside and outside the EU. In this

context highly trained professionals who understand and can apply the latest technology, international trade rules, and environmental frameworks, are essential to secure practical and sustainable development solutions in wood energy production. This challenge has been addressed by six higher educational institutions and bioenergy research organizations from across Europe. The consortium, in the framework of the EU Erasmus Multilateral Programme, is developing a masters program for educating experts in wood energy production, trade, and transportation as well as modern research and development methods, within the EU and globally. The relevant stakeholders in the sector of wood energy had been interviewed by means of a questionnaire and online survey to better understand their view of this sector and which skills they consider essential in master of science professionals. The outcomes of the survey are here analyzed and the resulting structure of the masters curriculum is described.

Decision-support tools for sustainable rural development: the case of the alpine area of Como Lake, Italy. Martire, S. (*European Forest Institute, Finland; salvatore.martire@efi.int*).

Local policies aim to merge the needs of local communities with the objectives of multi-level regulations. For European rural areas, the role of forests in leading rural development is growing, as emphasized by the EU Forestry Strategy 2013, and their role as a source of fuel is well-known. Usually, economic feasibility is the main constraint for developing local energy facilities. Indeed, developing sustainable forest-energy chains is crucial to preserving ecosystem services and overall environmental quality, thus ensuring social and economic benefits. Decision-making should be supported by assessment tools able to consider different aspects related to the sustainability of processes. This paper aims to illustrate how sustainability impact assessment and carrying capacity evaluation can synergistically lead decision-making processes through exploration of tradeoffs between multi-functionality of forests and needs of natural resources. Specifically, this assessment aims to support the planning of a local bioenergy chain in the alpine area of Como Lake, where local authorities believe that developing bioenergy chains can lead the development of rural areas. The main challenge has been to deal with fragmentation and inconsistency of data. Nevertheless, it has been possible to get useful results for local decision-makers to get a big picture of the forestry sector and valuable quantitative information on different energy development scenarios.

Fear of crime in urban parks—Do age, gender, and ethnicity makes a difference? Maruthaveeran, S. (*University of Copenhagen, Denmark; sree@life.ku.dk*), Arnberger, A. (*University of Natural Resources and Life Sciences (BOKU), Austria; arne.arnberger@boku.ac.at*), van den Bosch, C. (*University of Copenhagen, Denmark; cck@life.ku.dk*).

Although the many benefits of urban green spaces are usually emphasized, these environments also provide some disservices. For example, encounters with natural threats may evoke strong fear or other negative emotions. However, very few studies have examined the negative emotions associated with urban green spaces, particularly regarding social danger, such as fear of crime. This questionnaire survey (N=657) was conducted in the city of Kuala Lumpur, Malaysia, in an attempt to examine the effects of different age, gender, and ethnic groups on fear of crime in urban park settings. Manipulation of the environmental and social cues was represented via photographs created using Adobe Photoshop 6.0 software. Respondents were requested to view a set of 12 manipulated photographs and rate their perceived threat for each photograph by using a seven-point Likert scale. Analysis of descriptive statistics showed that photos with evidence of social disorder (for example, graffiti, trash, low maintenance), with high levels of concealment, and without the presence of other people were considered the most fear evoking. Photos without the presence of physical disorder, with low concealment, and with the presence of others were considered less fear evoking. The results of the independent t-test revealed that female respondents were significantly more likely to feel fearful than male respondents ($p < 0.001$). No difference was found between different age and ethnic groups. The subsets of respondents in each age and ethnic group are too small to justify detailed analysis of the results.

Perceived personal safety in urban parks through the eyes of urban park users of Kuala Lumpur. Maruthaveeran, S. (*University of Copenhagen, Denmark; sree@life.ku.dk*), Arnberger, A. (*University of Natural Resources and Life Sciences (BOKU), Austria; arne.arnberger@boku.ac.at)*, van den Bosch, C. (*University of Copenhagen, Denmark; cck@life.ku.dk*).

Although the many benefits of urban green spaces are usually emphasized, these environments also provide some disservices. For example, encounters with natural threats may evoke strong fears or other negative emotions. However, very few studies have examined the negative emotions occurring in urban green spaces, particularly regarding fear of crime. This study attempted to examine the effects of environmental cues and social cues on fear of crime in urban park settings. Manipulation of the environmental and social cues was represented via photographs created using Adobe Photoshop 6.0 software. Respondents were requested to view a set of 12 manipulated photographs in an urban park setting. As they looked at each scene, they were asked to imagine that they were actually in that setting walking alone and moving towards the situation in the photograph. The respondents were then asked to rate their fear of crime for each photograph by using a seven-point Likert scale. Analysis of data based on the Fisher and Nasar model (1992) found that photographs with lower levels of potential refuge and with the presence of disorder (for example, graffiti, lack of maintenance) appeared to be perceived with more fear. However, the presence or absence of people (social cues) in the photographs seems not to have any effect on the fear of crime.

Carrying capacity approach to forest management in developing countries. Masuda, M., Iwanaga, S. (*University of Tsukuba, Japan; masuda.misa.gm@u.tsukuba.ac.jp; iwanagasage@yahoo.co.jp*), Shiga, K. (*University of Tokyo, Japan; shiga@anesc.u-tokyo.ac.jp*), Prasetyo, L., Damayanti, E. (*Bogor Agricultural University (IPB), Indonesia; lbprastdp@yahoo.com; e11yn.d4mayanti@gmail.com*).

Demands on forests and forest land have been transformed by changes in external conditions such as economic globalization. Human impacts on forest ecosystems caused by commercial motivations have become common aspects in rural societies of developing countries, and conventional forest dependency models like non-timber forest products (NTFPs) for subsistence should be examined in present-day contexts. As forests decrease in size and deteriorate and the population continues to rise, holistic approaches to forest management, particularly in developing countries, are called for. This report focuses on carrying capacity of forests and presents an estimation how many people can be economically supported by a unit area of forest. Because the longer value chain in forest products compared to agricultural products makes such estimation difficult, the authors applied a raw

material production model to micro-scale forests and surrounding societies. An example was selected from long-rotation teak plantations and another was from short-rotation plantations. Both examples were in Java Island, which faces extremely high population pressure. The results suggested that multiple uses of forest resources and forest land could increase carrying capacity, yet the current situation shows the local community's dwindling dependence on NTFPs.

Implementing REDD+ in community managed forests: lessons from India. Mehra, S., Reddy, M. (*Iora Ecological Solutions, India; swapan@ioraecological.com; mohan@ioraecological.com*).

This presentation explores how REDD+ and potentially other payments for ecosystem services (PES) mechanisms can be integrated into community-based forest management to reward conservation and increase in forest cover. The presentation proposes a governance-, benefit-, and responsibility-sharing model which demonstrates how different stakeholders including the communities, forest departments, investors, and community-based organizations (CBOs) will interact to ensure the success of a project. The project proposes a multi-tiered framework to ensure cost-effective monitoring of carbon and non-carbon benefits from a project. These benefits include biodiversity and community benefits. The presentation uses information from case studies in Garo Hills, Meghalayal; Kohima, Nagaland; Tilari Region, Maharshtra; Shimoga, Karnataka; and other areas where the authors are engaged in developing pilot REDD+ projects in partnership with various CBOs, national and international agencies, and forest departments.

Linking quantitative projections and qualitative scenario methods for modeling ecosystem services from forest landscapes. Mozgeris, G. (*Aleksandras Stulginskis University, Lithuania; gintautas.mozgeris@asu.lt*), Brukas, V. (*Swedish University of Agricultural Sciences, Sweden; Vilis.Brukas@slu.se*), Kavaliauskas, M. (*Aleksandras Stulginskis University, Lithuania; marius.kavaliauskas@asu.lt*).

This study explored methodological as well as applied aspects of linking qualitative methods of scenario planning with forestry decision support tools, via modeling the behavior of involved private forest owners and state forest managers. The study is illustrated with results from two case study areas in Lithuania that are part of the EU FP7 project "Future-oriented integrated management of European forest landscapes" (INTEGRAL). The case areas differ substantially in biophysical and social characteristics, e.g., trees species distribution, ownership structure, and role of forests in the local economy. Four alternative possible future scenarios will be developed for each case area, envisioning different trajectories of multiple factors, including forest product markets, European and national policies, and silvicultural paradigms. Next, the Lithuanian large-scale forestry scenario model "Kupolis" will be adapted to perform a kind of agent-based modeling, reflecting potential behaviors of different types of forest owners or managers. Even though wood products currently have a very high market value, the potential values of carbon sequestration, recreation, environmental protection, and water will be assessed. Outcomes under the various scenarios will allow potential combinations of ecosystem services as well as alternative mixes of forest policy instruments to be evaluated.

GIS and monitoring of urban forests in Boa Vista, Roraima, Brazil. Neto, E.L., Reisq, F., Pinheiro, F. (*State University of Roraima, Brazil; everaldo.limaneto@gmail.com; flr_77@hotmail.com; flavia_abreu@hotmail.com*), Batista, D.B. (Federal University of Paraná*, Brazil; dbiondi@ufpr.br*).

The lack of planning for urban forests is common in Brazilian cities. The objective of this research was spatially registering the existing trees on the streets of the city of Boa Vista, through GIS. The authors traveled all the streets of the city, in order to collect points using GPS and measure the area of the tree canopy. It was observed that 73% of the streets have some type of pavement or urban infrastructure basic conditions. Use of GIS indicated that about 40% of the streets and blocks analyzed showed conditions suitable for trees along sidewalks. The area of the tree canopy was 0.15 mile^2. The relationship between crown area and the area of city sidewalks indicated that at least 7,000 trees could be planted along sidewalks, to meet aesthetic, ecological, and social needs. It was found that GIS provided spatial analysis of the distribution of trees in the municipality and provided information about neighborhoods with a deficit or surplus of trees. Thus, it is confirmed that the application of GIS is useful to support the implementation and monitoring of urban forests.

Determinants and global patterns of bushmeat hunting. Nielsen, M., Pouliot, M., Meilby, H., Smith-Hall, C. (*University of Copenhagen, Denmark; mrni@ifro.ku.dk; mapo@ifro.ku.dk; heme@ifro.ku.dk*), Angelsen, A. (*Norwegian University of Life Sciences, Denmark; arild.angelsen@umb.no*).

Bushmeat hunting is considered the main threat to conservation of biodiversity in tropical forests but simultaneously represents an important source of protein and income to innumerable rural households in the developing world. Many policy recommendations focus on creating alternative income-generating opportunities for hunting households as the main strategy for reducing the commercial bushmeat trade. However, results of existing studies are ambiguous, and the effect of the opportunity cost of labor on hunting has not been empirically investigated on a global scale. Similarly, there are contradictory results on how poverty, market access, and macro-economic conditions and stability influence bushmeat trade. Here the authors use the global Poverty and Environment Network (PEN) dataset containing more than 8,000 households in 35 tropical countries to investigate the socioeconomic, demographic, and geographical correlates of bushmeat subsistence and cash income and how the opportunity cost of labor affects bushmeat income. A probit model was used to examine household characteristics, and a mixed model was used to incorporate the panel data structure to analyze the relationship between bushmeat hunting and opportunity cost of labor. The results uncover information on the driving factors of the bushmeat trade, thereby facilitating design of management strategies without compromising rural livelihoods and food security.

Desired forest futures of forest sector stakeholders in Sweden. Nordin, A. (*Swedish University of Agricultural Sciences, Sweden; Annika.Nordin@slu.se*).

The Future Forests interdisciplinary research program explores pathways forward for the Swedish forest sector in a time characterized by change. During early 2014 this program will do a scenario-analysis involving four categories of stakeholders.

The methodology will be back-casting to explore desired forest futures for 2060 of four major categories of stakeholders. They are defined based upon differences in fundamental ideas of future forest use: (1) forest for production, (2) forest for conservation, (3) forest for indigenous people's heritage (e.g., reindeer herding), and (4) forest for recreational needs and rural tourism business opportunities. The back-casting methodology allows for decoupling futures from current trends, and enables definition of alternative pathways. Hence, stakeholders may move outside prevailing paradigms and ignore dominant trends. In the process, stakeholders' concepts, attitudes, and values will be studied. This presentation shows the four desired forest futures resulting from the back-casting analysis. In particular, similarities and differences of the desired futures will be highlighted. The presentation will also identify tradeoffs and choices that have to be made by society in a discussion of possible pathways forward to a common desired forest future.

Anchor forests: a multi-ownership pilot project in eastern Washington, USA. O'Laughlin, J. (*University of Idaho, USA; jayo@uidaho.edu*), Andringa, S. (*Yakama Nation, USA; steve@yakama.com*), Gervais, B. (*Northwest Advanced Renewables Alliance, USA; gervaisbreanna@gmail.com*).

An "anchor forest" is a multi-ownership land-based area capable of supporting sustainable long-term wood and biomass production levels backed by local infrastructure and technical expertise, and endorsed politically and publicly to achieve the desired land management objectives. It is a landscape-scale collaborative approach to active forest management with three main goals: restore infrastructure capacity, coordinate management across ownerships, and provide economic benefits. The Intertribal Timber Council, with U.S. Forest Service funding, is conducting a pilot project test of the concept in three areas of eastern Washington that include forest lands on four Indian reservations. The Yakama Nation, with 1.3 million acres of prime forest, grazing, and fertile farm lands in south central Washington state (USA), is the first part of the test. Team members include U.S. Forest Service and Washington Department of Natural Resources representatives and researchers from the University of Washington, The Nature Conservancy, and the University of Idaho. Progress to date will be highlighted, including resource assessment, collaborative cross-ownership strategies, and identification of barriers to meeting goals and management objectives.

Morphological assessment of *Parkia biglobosa* accessions from different agro-ecological zones in Nigeria. Onilude, Q., Akinyemi, O., Julius, A. (*Forestry Research Institute of Nigeria; omoonilu@yahoo.com; akinyemi77@yahoo.com; talktobayo247@yahoo.com*), Oduola, M. (*Federal College of Forestry, Nigeria; abilacrown@gmail.com*), Ogunremi, O. (*National Biotechnology Development Agency, Nigeria; sijiogunremi@yahoo.com*).

Twenty-nine accessions of *Parkia biglobosa* were collected from different agro-ecological zones in Nigeria to quantify the extent of morphological variation existing within the accessions. A completely randomized design was used with four replicates and five seedlings per pot for the 29 accessions. Morphological variations were evaluated by ANOVA, cluster analysis, principal component analysis (PCA), and Pearson correlation coefficients. Characters inferred showed differences across the accessions, except for a few variables, such as primary leaflets on cataphyll, stem girth, and root dry weight. Cluster analysis indicated the existence of three groups separating the species and revealing intra-specific variation within the accessions. An acceptable solution for PCA was reached when three dimensions of the model were found to be significant and explained 77% of the total variance of the original variables. Low genotypic and high phenotypic coefficient of variation was observed for all the characters measured. Overall highest value of genetic coefficient of variation was noticed in height of seedling, followed by average number of secondary and primary leaflets on seedling, average number of leaves on seedling, root dry weight, cataphyll length, cataphyll width, and fresh and dry weight of shoot.

Assessment of honey and its utilization on the rural livelihoods in the rainforest ecological zone of Nigeria. Onilude, Q., Oyeleye, B., Julius, A. (*Forestry Research Institute of Nigeria, Nigeria; omoonilu@yahoo.com; bolarinwa_oyeleye@yahoo.co.uk, talktobayo247@yahoo.com*, Ogunremi, O. (*National Biotechnology Development Agency, Nigeria; sijiogunremi@yahoo.com*), Oniroko, N., Jegede, O. (*Forestry Research Institute of Nigeria, Nigeria; onirokoniyi@yahoo.com; opeyemijegede@yahoo.com*).

The objective of this paper was to assess the impact and utilization of honey as a non-timber forest product on rural livelihoods in Iwo local government areas of Osun state situated in the tropical rainforest ecological zone of Nigeria. A pre-tested questionnaire was administered to 20 household heads from five villages selected using simple random sampling technique. Information collected included level of awareness of and willingness for successful adoption and integration. Results obtained indicated that the respondents' occupation included farmers (38.5%), civil servants (18%), traders (38%), and traditional healers (6.5%). The result of the descriptive and inferential test statistics showed that the perception of respondents on importance and uses of honey in the study areas varied. The major constraint discovered was that the traditional healers lacked quality control measures and did not have a standard way of measuring how much honey to use to treat different ailments. Honey production is predominantly an activity of rural people and can create employment, reduce poverty, and generate income, thus discouraging them from moving to urban areas for unavailable white collar jobs. Recommendations were also suggested based on the study.

Determinants of unwillingness in private forestry in the humid zone of Nigeria. Onyema, M. (*Federal University of Technology, Nigeria; mac-anthony.onyema@futo.edu.ng*), Azeez, I. (*University of Ibadan, Nigeria; azeezismail2000@yahoo.com*).

Public sector dominance of forestry across the globe impedes realization of local and international forestry targets despite huge local and international investments in the sub-sector. Groups and individuals with stakes in forestry were identified through stakeholder analysis across selected rural and urban communities in the study area. Relevant information was obtained using a set of questionnaires and supplemented with focus group discussions. Baseline data on household forestry-based activities were presented in the form of a checklist, and further analyses of data used Chi-square test of independence and logit regression models. Unwillingness by indigenous residents and local-based farmers was significantly influenced by household size and conservation awareness. Traditional/religious leaders and landlords (landowners) in both communities surveyed correspondingly expressed resistance to promulgate or support forestry/conservation issues or practices. Local-based farmers and indigenous residents in rural areas manifested inherent fear of any land use change because of prevalent local norms and institutionalized

practices in these areas. A robust and integrated grassroots approach towards a review of institutions and orientations of different categories of stakeholders is a step to develop an adaptable plan and synergy to encourage private sector forestry entrepreneurship.

Community perspectives for cacao-based agroforestry development in Camalig, Albay Province in the Philippines: an application of Q methodology. Paras, F. (*University of the Philippines, the Philippines; fdparas@gmail.com*), Rahman, S. (*Center for International Forestry Research (CIFOR), Indonesia; sumonsociology@yahoo.com*).

Albay province is considered to be the "Vatican of Disasters" in the Philippines due to the frequency of natural phenomena like typhoons, landslides, and volcanic eruptions in the area. However, amidst the threats aggravated by climate change, the province has a local government that is one of the most progressive in climate change mitigation and adaptation. As an adaptive management mechanism, a proposal for establishing a cacao-based agroforestry project in the community of Camalig, Albay, is being piloted in order to simultaneously address reforestation, climate-change adaptation, and poverty in the area. In this paper, the suitability of cacao-based agroforestry as a social enterprise, an adaptive management mechanism, and livelihood opportunity for the local community is assessed through key informant interviews, focus group discussions, and the application of Q methodology in analyzing community perspectives.

Valuing recreation for New Zealand's planted forests: moving beyond traditional timber economics towards achieving multi-purpose forests. Pizzirani, S., Yao, R., Lerouxdebretagne, F., Harrison, D. (*Scion, New Zealand; stefania.pizzirani@scionresearch.com; richard.yao@scionresearch.com; fanny.lerouxdebretagne@scionresearch.com; duncan.harrison@scionresearch.com*).

Forest recreation in New Zealand is a growing, multi-million dollar industry. Yet there is limited understanding of the economic value of a forest recreational visit for the tens of thousands of forest users in New Zealand. This study aims to examine the values and preferences of recreationists in New Zealand forests with high visitation rates. The objectives of the study were to: (1) estimate the economic value of recreation in forests; and (2) identify recreational preferences. To achieve these objectives, this research developed and implemented a nationwide survey using the travel cost method, the contingent behaviour method, and the Delphi method. Survey results indicated that for planted forests with high visitation rates, the economic benefits of recreation can exceed timber revenue. Furthermore, using identified recreational preferences, a matrix of potential economic value was developed which can be used when considering the development of a new forested area. This matrix was integrated with GIS to spatially identify land area suitable for both timber production and recreation. This research has allowed the authors to assess not only current economic benefits of forest recreation but also to optimise the socioeconomic potential of developing new forests.

Efficient and effective control of bark beetle outbreaks in a community forest of Oaxaca, Mexico. Poloni, A. (*Centro Interdisciplinario de Investigación para el Desarrollo Integral Regional Unidad Oaxaca, Mexico; adrian_poloni@live.com*), Duran, E. (*Instituto Politecnico National (CIIDIR-Oaxaca), Mexico; eduran3@hotmail.com*), Cruz Avilés, J., Maldonado Arango, O. (*Comisión Nacional Forestal, Región V-Oaxaca, Mexico; jucruz@conafor.gob.mx; olivia.maldonado@conafor.gob.mx*).

In recent years climate change has appeared to increase forest pest outbreaks, which can cause economic impact to the timber industry and alter the capacity of forests to provide environmental services. Current management models around the world for controlling forest pest outbreaks, such as those for *Dendroctonus* species, include varying levels of participation from government, industry, and other actors. Between 2007 and 2012 Mexico's National Forestry Commission (CONAFOR) detected 210 forest pest outbreaks throughout the state of Oaxaca; CONAFOR and 64 communities collaborated effectively to carry out forest management measures that reduced and almost eliminated many of the damaged forest patches. The governing institutions of community forests are essential in facilitating rapid, effective, and relatively economical forest health measures that address and control forest pest outbreaks. The community forests in Oaxaca have been recognized for their contribution in avoiding deforestation and promoting conservation; however, their crucial role in facilitating forest health measures goes unacknowledged. These cases offer successful examples of multi-scale governance, where local communities in forest resources are assisted by forestry professionals and state and federal agencies to execute efficient and effective management that promotes forest health. With the potential increase of forest pest outbreaks, more attention and support must be given to this trio of stakeholders.

Risnjak National Park: visitor vulnerability on the Leska educational path and suggestions to avoid unfortunate outcomes. Poštenjak, F. (*Independent, Croatia; fran.postenjak@gmail.com*).

National parks are places of significance that preserve natural landmarks. Risnjak National Park in Croatia was established mainly to protect its forests, which need to be preserved in unaltered form for future generations. Almost all (>98%) of the Leska educational path in the park goes through forest communities that have not been managed in any way over the past few decades. As a result trees representing a variety of hazards, such as deadwood, rotten trees, lightning-damaged trees, fungi-infected trees, and drywood, are found along the path. Visual tree assessment was conducted along the same portion of the path on two occasions in summer 2011 and in summer 2013. Most hazard trees found along the path were in zone A (50%), and the fewest were found in zone B (23%). Trees in the "3" hazard category were most common (40%) and those in the "2" hazard category were least common (27%). Contingent valuation method-willingness to pay was conducted between April and October 2013. Based on survey results it would be acceptable to raise the entrance fee for Risnjak National Park if the additional income would ensure visitor safety, infrastructure enhancement, and establishment of new activities. The visual tree assessments conducted on the Leska educational path indicate that visitor safety is at risk and that hazard sources should be removed.

Relevance of REDD initiatives for local communities in a low biomass forest: case of tapia woodland, central part of Madagascar. Rakoto Ratsimba, H., Rabemananjara, Z., Rabefarihy, A. Rabenilalana, F (*Université d'Antananarivo, Madagascar; rrharifidy@moov.mg; zorabema@hotmail.com; yrihat@gmail.com; rmihajamanana@yahoo.fr*), De Haulleville, T. (*Université de Liège-Gembloux Agro-Bio Tech, Belgium; tdehaulleville@doct.ulg.ac.be*), Bastin, J., Bogaert, J., Ramamonjisoa, B.

The success of the REDD initiative will depend on full involvement of local communities in the sustainable management of forest resources. In this sense, four key points need to be analyzed: (1) how to determine the available biomass in the *tapia* woodland, (2) trends of deforestation and degradation, (3) locations of these processes, and (4) needs of local communities in forest resources. This study combines multi-temporal remote sensing analysis integrating high resolution sensors combined with an inventory of biomass in the field with a stratified systematic random sampling at the forest level (forest class), and a socioeconomic study to identify the actors of deforestation/degradation and analyze their consumption practices of forest timber products. These analyses demonstrated that the *tapia* is a low biomass forest with an average of 20 ± 2 Mg/ha of dry biomass. Anthropogenic pressure on *tapia* woodland is high and is characterized by a continuous deforestation (a rate of 3% between 1990 and 2000 and 7% between 2000 and 2005). The surveys confirmed this trend and showed that local communities are the major actors of deforestation, mainly by firewood harvesting, charcoal production, construction, and conversion of forest land to cultivated land.

Integrating social science research class into the forestry curriculum: a case study of Forestry Engineering Program in Colombia. Rodriguez, S. (*Universidad Autónoma de Chihuahua, Mexico; sandra_osu@yahoo.com*), Villarraga, L. (*Universidad Distrital, Colombia; lizfvf@yahoo.es*).

Community-based sustainable forest management implies a commitment to understanding local sociocultural and economic aspects associated with resource management. Studies have shown that traditional knowledge is essential for forest management. Consequently, efforts have been done to encourage participatory practices to strengthen collaborative outcomes. However, little has been said about the challenges facing facilitators or professional foresters when communicating with forests' owners and indigenous populations of the forests. This study aims to investigate to what extend is the social dimension included in the forestry curriculums. An in-depth review of the undergraduate curriculums and class's syllabus with social component is conducted to determine the state of the art of the social dimension in those curriculums. A survey of 27 questions is administered to senior undergraduate students, professors, and professionals to explore the challenges faced when working with small-scale forests' owners and to assess perceptions about the importance of including formal classes on qualitative and quantitative social research. Data collection is in progress.

Forest research institutions and Caçador Model Forest: integrating local knowledge and scientific approaches to enhance rural livelihoods in Southern Brazil. Rosot, M. (*EMBRAPA, Brazil; augusta_rosot@hotmail.com*), Kellermann, B. (*National Council for Scientific and Technological Development* (*CNPq), Brazil; kdbetina@hotmail.com*), Radomski, M., Lacerda, A., Garrastazu, M. (*EMBRAPA, Brazil; maria.radomski@embrapa.br; andre.biscaia@embrapa.br; marilice.garrastazu@embrapa.br*), Cardoso, D. Mattos, P., Muñoz-Braz, E., Rosot, N., Oliveira, Y.M.

Though very restrictive, environmental laws—which prohibit any kind of management for timber production in Araucaria forest in southern Brazil—fail to prevent its conversion to other more profitable uses, mainly agriculture and livestock. Therefore, EMBRAPA Forestry, the forest branch of the Brazilian Agricultural Research Corporation, is putting much effort into demonstrating that the management of native forests can not only rehabilitate ecosystem functions but also contribute to increased rural incomes through alternative uses of forest resources. As a strategy to implement this paradigm shift, EMBRAPA has undertaken a 5-year process to create a model forest in the region of Caçador (Santa Catarina State), which features the typical landscape pattern of Araucaria forest remnants, including forest patches, crops, pasture, industrial areas, and urbanized areas as well as forest plantations. Despite an economy based on the service sector, commerce, agriculture, and a strong forest-based industry, the region has a low Human Development Index, poor income distribution, and environmental liabilities. Aiming at enhancing rural livelihoods within the model forest, EMBRAPA and other research institutions are developing projects that integrate the community's practical knowledge and scientific methods concerning sustainable forest management through participatory field-level methodologies, as well as facilitating cross-sector relationships involving forestry and agriculture.

Forest offenders become the protector of the forest: a case study from inland Sal forest, Bangladesh. Sadath, M. (*Khulna University, Bangladesh & Georg August University, Germany; mnsadath@yahoo.com*), Islam, M. (*University of Queensland, Bangladesh; wasiulislam7@yahoo.com*).

Forest encroachment by local forest users and indigenous people has been the root cause of inland Sal forest destruction in Bangladesh. The Madhupur National Park and adjacent forest areas have lost biodiversity and vegetation cover. Until 2008, frequent burning and illegal logging were common under the policing type of traditional forest management by the forest administration. This study examined the change in forest biodiversity and number of forest offences in the Madhupur region before and after implementation of the innovative Bangladeshi co-management model. Quantitative and qualitative content analysis, followed by interviews of relevant stakeholders, was used to analyse the social and political aspects of this forest area. Regeneration and forest biodiversity were assessed in 2006 and 2013. The study found that the status of forest vegetation and biodiversity improved, and the number of forest violations has decreased, dropping from 276 offences in 2003–2004 to only 23 in 2011–2012. This study shows that when the forest offenders were made the protector of the forest in the Madhupur region, the co-management strategy was successful.

Evaluation of the tree mortgage system in traditional agroforestry management in Moluccas, Indonesia. Salampessy, M. (*Pattimura University, Indonesia; meis_forester@yahoo.com*), Febryano, I. (*Lampung University, Indonesia; indragumay@yahoo.com*), Suharti, S. (*Ministry of Forestry, Indonesia; suharti23@yahoo.co.id*).

The agroforestry system in land management has been carried out traditionally by the societies in Maluku, Indonesia. The practice is known as "Dusung," and one of the plants cultivated is nutmeg. Although currently world demand for nutmeg is extremely high, this demand has no effect on farmers' welfare. Farmers face a number of problems, one of which is a system of debt bondage that causes heavy losses to farmers. This study aims to explain the involvement of farmers with the debt bondage system, namely "the tree mortgage system." The method used in this research is a case study, where data are collected by interviewing and observing participants. The collected data were analyzed using principal agent theory. The results showed that

nutmeg farmers have a high risk of debt bondage due to exploitive and unethical treatment by bond agents. This can occur, for example, when agents use their knowledge of nutmeg marketing prospects (i.e., prices) to pay unfairly low prices to farmers. Farmers are also required to mortgage the nutmeg tree with a particular agent, through loans provided by the agent, which puts farmers in a weak and disadvantaged position.

Promoting community forestry in a REDD+ context: a global analysis of small-scale forestry enabling environments in 44 developing countries. Sanchez Badini, O. (*University of British Columbia, Canada; olivia.sanchez@alumni.ubc.ca*).

Small and medium forest enterprises, including community forestry, are common business models in the context of forest-dependent economies in developing countries. Because these enterprises can contribute to the achievement of REDD+ goals through conservation and sustainable use of forests while simultaneously improving local livelihoods, it has been proposed to use a portion of the REDD+ readiness efforts to promote national enabling environments for fostering the development, growth, and success of these enterprises. Using an evaluative framework created from an extensive literature review on the subject of small-scale forestry enabling environments, this work used qualitative content analysis to explore the breadth and depth of national-level support for external and internal elements of success for small and medium forest enterprises. The study focused on 60 REDD-readiness Forest Carbon Partnership Facility (FCPF), Climate Investment Funds (CIF), and UN-REDD documents from 44 different developing countries in Latin America and the Caribbean, Africa, and Asia-Pacific. By understanding the role of these REDD+ schemes in the direct and indirect promotion of small-scale forestry development in various countries, the authors aim to understand the global trends in this area and point out gaps in the enabling environment found in the current strategies and actions proposed under REDD+.

Management of regeneration on hurricane-affected forests and its implications for the development of indigenous communities in the North-Atlantic Region, Nicaragua. Sánchez Correa, J. (*Colombia; jeanbap563@hotmail.com*), Ordoñez, Y. (*Independent; yadido@hotmail.com*).

In the first half of 2011, an ecological characterization of forests affected by Hurricane Felix, 3 years earlier, was performed in the North-Atlantic Autonomous Region, Nicaragua. In addition to use of the livelihoods approach, resources of Miskito communities were described and information on forest management in the study area was compiled. The results were shared with both the local community and the forestry advisory body of the region. Based on the results, guidelines for forest management, mainly for regeneration, were defined to enable local indigenous people to develop skills and potential leverage for obtaining benefits. From an ecological perspective, a recovering forest with abundant regeneration of useful species—*Calophyllum brasiliense, Symphonia globulifera, Terminalia amazonia, Vochysia ferruginea, Vochysia guatemalensis*, and *Carapa guianensis*— was found. From a social perspective, communities with strong natural, social, and human resources were also found, represented by recovering forests, organizational structures, and skillful and specialized labor, respectively. Based on the degree of forest recovery and environmental conditions, and taking into account community resources, silvicultural treatments have been proposed—release of species and desirable individuals, sprout management, seed production, and gap enrichment with species of commercial interest—to manage the forest and get a desired species composition that meets community expectations.

Eradicating an invasive species: landowner perceptions of impacts to ecosystem services. Santo, A., Sorice, M. (*Virginia Polytechnic Institute and State University, USA; anna.santo@vt.edu; msorice@vt.edu*), Anderson, C. (*Centro Austral de Investigaciones Científicas, Argentina; chrisa1@vt.edu*).

Originally brought to the Tierra del Fuego (TDF) archipelago in Argentina to start a fur trade in 1947, the North American beaver (*Castor canadensis*) has spread throughout the region. Despite binational support for eradication, *estanciero* (private landholder) participation in beaver control has been very low. The authors conducted 40 semi-structured interviews on the main island of TDF to examine *estancieros*' mental models of how beaver-caused changes influence riparian area ecosystem services. The authors further examined the influence of these perceptions on the willingness of *estancieros* to assist with beaver eradication. Individual mental models were aggregated into an overall cultural model to examine the degree of shared understanding about beaver impacts to ecosystem services. Many landowners perceived beaver as a threat to provisioning, cultural, supporting, and regulating services; however, a minority of landowners in the arid north perceived significant personal provisioning and cultural service benefits. Lack of cooperation among neighboring landowners, especially public lands, was frequently mentioned as the largest barrier to participation in beaver control efforts. The authors suggest areas where targeted communication, regulation, or voluntary incentives might facilitate effective and cooperative beaver eradication strategies.

Small-scale private forests provide increased structural diversity and carbon storage in Germany's Swabian Alb biosphere reserve. Schaich, H. (*University of Freiburg, Germany; harald.schaich@landespflege.uni-freiburg.de*), Plieninger, T. (*University of Copenhagen, Denmark; tobias.plieninger@ign.ku.dk*).

In European cultural landscapes, forest area is subdivided into a mosaic of stands of different ownership types and sizes. This study hypothesizes that forest ownership is an indirect determinant of forest management approaches and is therefore relevant for biodiversity conservation and carbon sequestration. The authors compared structure and species composition of mixed deciduous forest stands in clusters of different ownership types, namely state-owned, municipal, and small-scale private forests, in south-western Germany. Although close-to-nature management has been practiced in public forests for years, this study demonstrated that tree species diversity does not differ significantly between ownership types. However, small-scale private forests comprise significantly higher levels of structural diversity, more dead wood, and greater carbon storage capacity than either public forest type. This finding is contrary to other studies, where publicly owned lands were found to host higher biodiversity, and differs from the global trend, where continued fragmentation of private lands threatens forest sustainability. The importance of small-scale private forests, e.g., for the conservation of old-growth and dead-wood-dependent species, appears to stem from less intensive and more diverse forest management. To maintain diversity in small-scale private forests, remuneration and consulting programs to promote forest biodiversity and ecosystem services should be advanced.

AgriCarb: an option for rural development in Gabon. Schmid, C. (*University of Natural Resources and Life Sciences (BOKU), Austria; carmen_schmid@gmx.at*), Niedermayr, J. (*University of Natural Resources and Life Sciences, Italy; julia.niedermayr@gmail.com*), Stanzl, P. (*VMS, Gabon; stanzl225@aon.at*), Pietsch, S. (*University of Natural Resources and Life Sciences (BOKU), Austria; stephan.pietsch@boku.ac.at*).

The AgriCarb project in Gabon, Africa, promotes a sustainable land-use scenario by linking smallholder low-input agroforestry with forest preservation and small-scale carbon offset projects. High transaction costs of carbon offset projects, along with low CO_2 prices and related risks and uncertainties, are major obstacles to smallholder project implementation. The aim of this study was to assess whether the implementation of an agroforestry system supported by carbon offset payments is likely to provide higher net income to farmers than their current shifting cultivation practices. A survey of the socioeconomic background and carbon stock measurements of forests as well as existing plantations was conducted to determine the baseline scenario of shifting cultivation. The current land areas used for shifting cultivation were found to be five times higher than the project scenario. Moreover, carbon stocks under the agroforestry scenario are estimated as at least 20% higher than the baseline carbon stock. Analysis of the economic performance of agroforestry implementation using net present value calculation, demonstrated additionality of the AgriCarb project: Higher initial costs of agroforestry implementation are estimated to be covered by offset payments and revenues from agroforestry production. Thus, carbon offset payments have been identified as a viable incentive for farmers to switch to agroforestry.

Subsistence strategies and means of the river populations of the Luki Biosphere Reserve in the Democratic Republic of Congo. Semeki Ngabinzeke, J. (*University of Kinshasa, Democratic Republic of the Congo; jeansemeki@gmail.com*), Meyanga Tongo, Y. (*Ministry of Scientific Research and Innovation- Yaoundé Cameroon, Cameroon; meyanga_yves@yahoo.fr*).

The Luki Biosphere Reserve, the last remnants of the Mayombe forest in the Democratic Republic of the Congo, is under severe anthropogenic pressure. Since independence, "Zairisation" has led to a cascade of bankruptcies in the agricultural and food industries in the region. Seeking a new livelihood, the people went to the forest, where slash and burn agriculture, charcoal production, timber exploitation, and hunting have been their means of subsistence. To understand these means of subsistence, surveys were carried out in four villages (Kinzua-Mvuete, Kikalu, Kiyalala, Kiyangala) located along the river in the Reserve. Results show the people's strong dependence on forest resources. In the context of a growing population, general impoverishment, and bad environmental governance, the people developed strategies of intensification, extensification, diversification, and migration. These activities result in insufficient fallow time, land conflicts, felling of small-diameter trees, and land use change, which together with deforestation and degradation strongly contribute to the people's state of misery. With a view to reconciling the objectives of development and conservation, recommendations include increasing the use of agroforestry, fish farming, and apiculture, and raising raise awareness.

Undergraduate enrollment in forestry and related areas of natural resources in the United States with respect to gender and race/ethnicity. Sharik, T. (*Michigan Technological University, USA; tlsharik@mtu.edu*), Lilieholm, R. (*University of Maine, USA; roblilieholm@gmail.com*), Richardson, W. (*U.S. Department of Agriculture, USA; billrich@vt.edu*).

Enrollments of women and minorities in forestry and related areas of natural resources in the United States are substantially lower than their numbers in the college population as a whole and in most other fields of study. When all areas of natural resources are examined, forestry shows the lowest enrollments of women and minorities. Interdisciplinary degree programs exhibit the highest numbers and are also the fastest growing programs overall. These trends have important implications for the future of the forestry profession in the United States.

Impact of socioeconomic circumstances on forest management and forest cover in Java Island, Indonesia. Shiga, K. (*University of Tokyo, Japan; shiga@anesc.u-tokyo.ac.jp*), Damayanti, E., Wachyuni, M., Prasetyo, L. (*Bogor Agricultural University (IPB), Indonesia; e11yn.d4mayanti@gmail.com; mardiana.why@gmail.com; lbprastdp@yahoo.com*), Masuda, M. (*University of Tsukuba, Japan; masuda.misa.gm@u.tsukuba.ac.jp*).

Deforestation constitutes the main problem in developing countries. Some proximate causes are agricultural expansion and forest exploitation. Driving forces include population increase, debt, government policies, and price of export commodities. Given these factors, deforestation would be expected to be a site-specific process and to differ based on biophysical and demographic characteristics of the site. Java Island is the most populated island in Indonesia with almost a quarter of the island in forestland. Java has a very long history of deforestation that started in the Dutch colonial era, but through forest management by *Perhutani* (State Forestry Corporation) and several other central-government programs, some provinces in Java have been attempting to extend the forest cover. The shift from deforestation to reforestation is called "forest transition." Among provinces in Java, West Java Province, where the forests are managed by *Perhutani* Unit III West Java & Banten, is the only province that has already experienced forest transition. This study was aimed at clarifying whether socioeconomic conditions affect forest management and forest cover in Java. Using statistical data and the annual report of *Perhutani*, the authors address the effects of (1) a change in forest management (including collaborative forest management between the community and *Perhutani*) and (2) offensive activities by local people caused by economic development and by changes in industrial structures, demographics, and local community relationships.

Local community resource management of the mangrove forest ecosystem at Kalitoko, Mayalibit Bay, and Raja Ampat, West Papua, Indonesia. Sihotang, B. (*Indonesia; godbless.binsar@gmail.com*), Yunita, S. (*Gadjah Mada University, Indonesia; yunitasekar95@yahoo.com*).

The mangrove forest ecosystem in Kalitoko in Indonesia has high biological productivity and also provides socioeconomic benefits to the community. This research aimed to determine the activities of the community affecting the ecosystem, describes socioeconomic conditions and community interaction in utilizing the mangrove forest, and evaluates the condition of the mangrove forest. The research was conducted from July to August 2012 in Kalitoko, Mayalibit Bay, and Raja Ampat. Data were

collected using purposive sampling by interviewing several people who have many activities within and near the forest. In addition, secondary data were obtained from a literature review. Results showed that fishing was the occupation of 71% of the community; fishermen utilized the resources of mangrove for their survival. Most people (53%) were aware of the importance of the mangrove in protecting flora and fauna to support the preservation of mangrove ecosystems. The diversity of species in this mangrove forest was relatively high. Sixty-five species of mangrove (56 genera and 35 families) were identified, of which 21 species were classified as rare species in accordance with their listing as "threatened" on the IUCN Red List. Tree density was 549 individuals/ha with basal area of 18.6 m^2/ha.

Linking mitigation and adaptation: learning from the first Indonesian community-based afforestation/reforestation Clean Development Mechanism project between Korea and Indonesia. Siregar, C. (*Forest Research and Development Agency, Indonesia; siregarca@yahoo.co.id*), Siregar, U. (*Bogor Agricultural University, Indonesia; siregaruj@gmail.com*), Jin, S. (*Korea International Cooperation Agency, Republic of Korea; spforest@gmail.com*), Lee, K. (*Korean Forest Service, Republic of Korea; jyakt@hotmail.com*).

Lombok Island, Indonesia, has the characteristics of a small island, such as low carbon emissions, but is highly vulnerable to climate change impacts because of limited natural resources, infrastructure, and human capital. The island has undergone massive deforestation under recently drier climate conditions. Agricultural productivity on the limestone-based soil is low and the local community is poor. In order to mitigate climate change in Lombok Island the governments of Indonesia and Korea conducted their first small-scale joint afforestation/reforestation Clean Development Mechanism (AR CDM) project under REDD+. From project implementation it was learned that mitigation alone was not sufficient to restore ecosystem services, such as water availability, while alleviating local poverty at the same time. Some adaptation measures are needed, such as building water reservoirs for plantation maintenance, establishing an agroforestry system that consists of a 1:1 planting ratio between forest and fruit tree species, and developing new market initiatives for agroforestry products linked to ecotourism.

Best practices for enhancing communication skills of forestry majors in U.S. institutions of higher learning. Storer, A., Sharik, T. (*Michigan Technological University, USA; storer@mtu.edu; tlsharik@mtu.edu*), Bullard, S. (*Stephen F. Austin State University, USA; bullardsh@sfasu.edu*), Allen, J. (*Northern Arizona University, USA; James.Allen@nau.edu*).

Communication skills have been identified by employers of forestry graduates as the top priority among all desirable skills in their employees ever since surveys of desirable skills have been administered. Moreover, communication skills typically show the greatest gap between desired and actual skill levels, both in our students and in our graduates in the workplace among an array of skills examined. In response to this problem, educators from the more than 70 institutions of higher learning offering forestry degrees in the U.S. have been developing best practices for enhancing communication skills. Here we report on these best practices, along with methods of measuring/assessing gains in these skills and the magnitude of these gains.

Conserving endangered species of high economic value through the participatory cultivation model. Suharti, S. (*Ministry of Forestry, Indonesia; suharti23@yahoo.co.id*).

Intensive and massive forest exploitation along with frequent forest fires in Indonesia has resulted in the immense decline of many tree species, including several of high economic value. At the same time, many conservation efforts have not had satisfactory results because programs have lacked focus and good planning. Furthermore, there are different perceptions about conservation terminology. Some people interpret conservation of rare plants as not allowing plants to be disturbed or cultivated for harvest at all. This perception needs to be modified because several conservation efforts through partnership models, such as that for aloes (*Aquilaria malaccensis*), have yielded positive and significant results. Research reveals that communities in various regions are quite enthusiastic about aloe cultivation because it could lead to many benefits. Some of the factors supporting success of aloe conservation through the participatory model are the widespread adoption of techniques for aloe, high economic value of aloe products, relatively short cultivation period (8 years), and availability of required technology for inoculation. Aloe tree conservation programs through the participatory model could be replicated for other endangered species with high economic value.

Merging gaps between forest conservation and agricultural production in protected areas: case study of southern Bakundu in Cameroon. Suka, E. (*Protection of Nature and Sustainable Development, Cameroon; emmanuelsuka@yahoo.com*).

The Southern Bakundu Forest Reserve was established in 1940. Today, in a search for arable farmland, communities near the forest boundaries have converted 7 000 ha out of the original 19 425 ha to cropland through slash and burn. Illegal chainsaw felling of timber and harvesting of non-timber forest products have further degraded the forest and increased carbon emissions. Land tenure conflicts are rife among stakeholders. Surrounding villages claim ownership of the land despite exclusive state ownership of forest reserves. Government met stiff resistance when it attempted to evict farmers from the reserves because the established farms have cash and subsistence crops. Despite rising demand for food, the government rejected requests to declassify the reserves and hand over the already occupied portions for agricultural production. To ensure that forest reserves continue to provide much-needed environmental goods and services, deforested areas were rehabilitated and standing forest improved to enhance carbon storage. Agroforestry systems and the consensual natural resource governance approach were implemented. Stakeholders jointly drafted and implemented management plans for forest and agricultural resources. Analysis of data showed a tremendous increase in agricultural productivity and stabilized forests. Results were used to develop REDD+ projects. Further damage to the forest was halted, thus stabilizing local climate and supporting food security and sustainable development goals.

Alternative livelihoods and biodiversity conservation. Sunderland, T. (*Center for International Forestry Research (CIFOR), Indonesia; t.sunderland@cgiar.org*), Roe, D. (*International Institute for Environment and Development (IIED), UK; dilys.roe@iied.org*), Redford, K. (*Archipelago Consulting, USA; redfordkh@gmail.com*), Kumpel, N. (*Zoological Society of London, UK; Noelle.kumpel@zsl.org*), Booker, F. (*International Institute for Environment and Development (IIED), UK; francesca.booker@iied.org*), Day, M. (*Center for International Forestry Research (CIFOR), UK; m.day@cgiar.org*).

Considerable investment has been made in strategies designed to provide alternative livelihoods for people living in and around protected areas or other areas of biodiversity. The primary aim of such interventions is to alleviate a threat to biodiversity; a strong secondary outcome is to improve the well-being of the targeted communities. The donor community has invested in alternative livelihood activities for decades as part of both poverty alleviation programmes and tied development and conservation projects. Despite these investments, very little is known about what has worked, and what has not worked and why. There is also very little information about how more effective new programmes can be developed for both conservation and sustainable livelihoods. This systematic review provides an overview of the state of the evidence base on the effectiveness of alternative livelihood projects and illuminates the strengths, weaknesses, and prevailing knowledge gaps. The primary research question for the systematic review is: "Are alternative livelihood projects effective at reducing local threats to defined elements of biodiversity and/or improving or maintaining the conservation status of those elements?"

What makes community forest management successful in Myanmar? Thu, P., Park, M., Koo, J. (*Seoul National University, Republic of Korea; phyothu@snu.ac.kr; mpark@snu.ac.kr; sele78@snu.ac.kr*).

In Myanmar, the forests and forest land are controlled by the state, and land can be converted to other land uses. Community Forestry Instructions issued by the Forest Department in 1995 represented an innovative approach to decentralization of forest management and became a path to more secure land tenure. According to the Forest Master Plan (2001), 2.27 million acres must be handed over to forest user groups (FUGs) by 2030–2031, but only 4.5% had been handed over after 15 years (by 2010). This paper aimed to determine whether community forests are functioning well and to identify the wide range of challenges that FUGs encounter. Based on the theory of public participation in natural resource management, the social factors that determine the function and progress of community forest management were identified in the two Myanmar cases. The roles of stakeholders and their relationship and formal or informal rules were examined in the process of community forest management. Hence, this paper will be helpful when considering reforms in the policies and institutions of community forest management in Myanmar as well as in other developing countries.

Analysis of different community-based forestry in relation to employment and local livelihood in Nepal. Uprety, D. (*Multi Stakeholder Forestry Programme (MSFP), Nepal; dharam.uprety@gmail.com*).

Community-based forestry (CBF) in Nepal is attracting international attention. CBF in this paper encompasses community forestry, collaborative forest management, leasehold forestry, and buffer zone forest management, where the sustainable management of forest resources and their sustainable utilization rights are handed over to local communities under an approved operation plan, and users' constitution. Data shows that there are about 29 000 community-based forestry groups managing about 1.9 million ha of forest across the country. A recently updated report from Department of Forest of Nepal shows that the number of community forest user groups (CFUGs) reached 18 133, with 2.2 million membership households managing 1.7 million ha of forest land. The community-led forests and forestry sector as a whole contribute to generating jobs, thereby providing different livelihood options. A study found that the forestry sector employs 9.2% of Nepal's total economically active population (23 million) and contributes to 9.4% of the national GDP. The paper is based on studies between 2011 and 2013 commissioned by the Multi Stakeholder Forestry Programme, of which the author of this paper is the climate change and forestry manager.

Building climate resilience in communities by integrating community practices into the local planning process in Nepal. Uprety, D., Subedi, R. (*Multi Stakeholder Forestry Programme (MSFP), Nepal; dharam.uprety@gmail.com; r-subedi@msfp.org.np*).

About 25% of the total population in Nepal lives below the poverty line (less than US$1.25/day). Most of the population living in poverty is forest- and agriculture-dependent and is the most vulnerable in the face of climate change. With the inevitable impacts of climatic change, poor and vulnerable communities in Nepal have started preparing strategies to cope with the climate-induced hazards through adoption of community-based adaptation plans. This paper is based on the review of 420 community adaptation plans (CAPs) prepared between 2009 and 2012 at 12 different districts and covering approximately 33 600 rural households in Nepal. Preliminary analysis shows that incidence of landslides, drought, and forest fire, has increased sharply in the last few decades. The most common adaptation strategies for local communities to cope with these events were plantations (364 communities), raising awareness (362), water management (366), income diversification (302), alternative energy promotion (271), crop diversification (217), establishment of an emergency fund (319), and forest management activities (318 communities).

Tourism activities and biodiversity conservation within protected areas in West Africa. Vodouhe, G. (*Laboratory of Applied Ecology, Benin; vodouhefifanou@gmail.com*).

Local community support for management of protected areas is essential for their sustainability. Support is often linked to the benefits that communities receive from the protected areas, and tourism development is a means of providing such benefits. However, very few studies have attempted to analyze the link between the receipt of tourism benefits and local people's support for biodiversity conservation. The present study carried out around Pendjari National Park (PNP) in West Africa examined local people's attitudes towards tourism activities, their perception of sharing tourism benefits, and the effects of this perception on local support for biodiversity conservation. Data were collected from 293 residents regarding tourism and biodiversity conservation in PNP. Results revealed that 70% of respondents were positive towards tourism and support biodiversity conservation within the park. Twenty-four percent of respondents participated in different tourism-related activities, such as tour guide (11%), hunting guide (8%), and host to tourists (6%) during their visits. About 97% of respondents support the principle of returning a part of benefits generated by tourism activities to local communities, but they are frustrated by the total amount returned (73% of respondents). Gender and compensation methods used are the two most important factors distinguishing residents' perception of the inequalities in tourism benefits sharing ($c^2_{(8)} = 72.65$; $p = 0.0001$).

Does participation in non-profit urban tree-planting programs improve neighborhoods? Examining the impact of collective action on neighborhood residents. Watkins, S. (*Indiana University, USA; shawatki@indiana.edu*).

Collective action between neighbors has been found to build community capacity and to build connections, trust, and reciprocity among individuals. Urban tree-planting nonprofits in many U.S. cities often require neighborhoods to be involved in tree planting and maintenance and often these nonprofits articulate program goals that include social outcomes like improved community capacity. The purpose of this research was to evaluate whether neighborhood participation in these urban forestry efforts increases community capacity, including the level of trust that neighbors have for one another, the ties between them, and cohesion in the community. This research leverages a unique dataset that includes both ecological and social information about tree-planting neighborhoods and matched comparable neighborhoods in five cities. The data include survey responses from residents and participants; interview responses from neighborhood leaders and nonprofit employees, and a suite of neighborhood spatial and sociodemographic characteristics. Hierarchical regression techniques will account for spatial clustering of individuals within neighborhoods. Preliminary results suggest that nonprofit tree-planting programs that require neighborhood involvement have positive effects on the community, including helping neighbors to meet and communicate.

The Komet Programme, a public-private partnership in forest protection. Widman, U., Sandström, C., Eckerberg, K. (*Umeå University, Sweden; ulrika.widman@pol.umu.se; camilla.sandstrom@pol.umu.se; Katarina.eckerberg@pol.umu.se*).

There is growing worldwide reliance on voluntary agreements such as public-private partnerships (PPPs) as a means for forest protection. In Sweden, such partnership characterizes the approach in nature conservation agreements (NCAs). These agreements are negotiated between the County Administrative Board/the Forest Agency and a landowner. However, assessments made by the Swedish Forest Agency show rather inefficient implementation of set goals, even if there are regional variations. Hence, another PPP, the Komet Programme, was established in 2010 in selected regions to increase the interest for nature conservation and NCAs among landowners. The Komet Programme differs from top-down protection, as it gives the initiative in nature conservation to the individual landowner and not to the authority responsible. However, the forms of protection and payment in the programme are the same as in traditional formal protection. This paper intends to explore, through interviews with key actors, what factors on a local level affect the process and formation of PPPs. The analysis focuses on the process among the actors and their incentives for collaboration on a voluntary basis. The results may decrease the knowledge gap regarding the process-related aspects of PPPs and how they differ from those of formal protection.

Joint forest management in Western Uganda – impacts of internal governance on local livelihoods and conservation. Wilms-Posen, N., Murer, C., Egas Cadena, J., Brandao, L. (*University of Copenhagen, Denmark; n.wilmsposen@gmail.com; carlo.murer@yahoo.com*, *jegas@aldhea.org; lu.rb.br@gmail.com*).

Joint forest management (JFM) has been promoted widely in Uganda. Outcomes of this approach have mostly been analyzed with regard to livelihood and conservation; therefore, this paper aimed to examine (1) how different governance aspects of JFM affected developments of community-based organizations (CBOs), and through which channels these developments affected (2) local livelihoods and (3) conservation outcomes. The paper applied a mixed method approach and collected data in two CBOs managing considerable areas of the Budongo Forest Reserve. Results show that internal governance is a critical determinant for performance of CBOs. Elite capture and poor conservation outcomes were observed in a CBO that experienced difficulties in building trust and effective internal communication. Internal governance also limited the possibility of poor community members to participate in JFM activities, as it reduced the expected net benefit of joining the CBO through the perceived high risk of misinvestment. A comparison between wealth of households and their date of joining the CBO underlines this relationship as poor households joined the CBO only after expecting to receive tangible benefits. The authors conclude that internal governance and social capital formation can affect distributional outcomes and the achievement of the overall objectives of JFM.

The role of dryforests in livelihood resilience: experience from the pastoral and agro-pastoral production systems in the drylands of Ethiopia. Worku Gizaw, A. (*Forestry Research Center of Ethiopia, Ethiopia; adefires@yahoo.com*), Pretzsch, J. (*Dresden University of Technology, Germany; pretzsch@forst.tu-dresden.de*), Kassa, H. (*Centre for International Forestry Research (CIFOR), Ethiopia; habtekassa@yahoo.com*).

Dryforests are the largest components of the landscapes and gene pool of the continent of Africa. Lack of data on their socioeconomic significance has hinder integration of dryforests into development planning and hence they have undergone massive deforestation. Guided by social-ecological co-evolution theory framework, mixed quantitative and qualitative research design was used to examine the significance of dryforest income and factors affecting dependence on it, in the context of the pastoral and agro-pastoral production systems in the drylands of Ethiopia. Results showed that dryforests were a vital part of households' income portfolio, contributing 34.5% of the annual income and 42% of the cash income. Dryforests were the largest income sources for 47% of the respondents, and contributed up to 63% of the annual income of the poor, mainly female-headed households. Income from dryforests helped 24% of the households remain above the poverty line and reduced income disparity (Gini coefficient) by 13.7%. Income from dryforests is increasingly becoming a key strategy in households' risk management planning and in their coping with drought episodes. Various factors influence dependence on dryforest income. Implications of these findings could be relevant to similar dryland ecoregions in the Horn and could contribute to promoting multi-level accountability in managing the diminishing dryforests. Adaptation of livelihoods could thereby be enhanced, combating desertification and biodiversity conservation.

Rural development with non-timber forest products: the case of Qiannan Buyi and Miao Autonomous Prefecture, Guizhouin, China. Xun, H. (*International Centre for Bamboo and Rattan, China; xunhang@icbr.ac.cn*), Matsuoka, S. (*Waseda University, Japan; smatsu@waseda.jp*), Yue, Y., Tang, F. (*International Centre for Bamboo and Rattan, China; yueyd@icbr.ac.cn; fengtang@icbr.ac.cn*).

In the remote and mountainous areas of western China, it is common to find poverty existing side by side with abundant forests. Development of utilization of non-timber forest products (NTFPs) would make a great contribution to rural development in China.

The general objective of the paper is to assess the contribution of NTFPs to rural livelihoods and to identify potential development interventions for the future improvement in the Qiannan area. Data was collected via a semi-structured household survey, focus group discussion, and informant interviews. The research findings suggested that the livelihoods of forest-adjacent people in the Qiannan area are directly connected to various types of forest products. Of all NTFPs, sea buckthorn (*Hippophae rhamnoides* Linn (Sha Ji)) and bamboo shoots provided the highest market value. However, forest farmers have poor awareness of biodiversity, and they usually manage forests and collect NTPFs in an unsustainable way. To make natural resource utilization sustainable, there are three types of policy approaches: command and control, market-based approaches, and voluntary approaches. A combination of these approaches would be an ideal way to maximize sustainability. Some recommendations for relevant social actors are made in this research.

General health condition of forest species in three parks in Mexico City: crown condition. Zaragoza Hernandez, A., Cetina-Alcalá, V., López-López, M. (*Colegio de Postgraduados, Mexico; zara407@hotmail.com; vicmac@colpos.mx; lopezma@colpos.mx*), Chacalo-Hilú, A. (*Universidad Autónoma Metropolitana-Azcapotzalco, Mexico; lchacalo@yahoo.com.mx*), Isla-de Bauer, M., González-Rosas, H. (*Colegio de Postgraduados, Mexico; libauer@colpos.mx; hectorgr@colpos.mx*).

The crown condition indicator is used to know the proportion of trees with a crown dieback or a foliage density considered lower than normal. Thick and large crowns relate to high growth rates whereas small ones suggest sites with unfavorable conditions. The crown condition indicator can provide adequate reliable information to diagnose the general health condition of urban trees. The sites chosen were parks within Mexico City known as Alamedas. Samples were collected on three occasions during the rainy season (May–October) and once during the dry season (November–April) of 2011. Variables recorded were crown density (DNC), crown dieback (MR), and foliage transparency (TRPF) in 5% intervals on a scale of 0 to 100. Normality tests, variance analysis, and a non-parametric Kruskal-Walis analysis were carried out to find the distribution of data and significant differences in the values of the three variables at the level of $\alpha = 0.05$. Results indicated that species in better health were those with the highest DNC values and the lowest TRPF and MR values. Species in the best health were *Cupressus sempervirens*, *Ligustrum lucidum*, *Populus alba,* and *Fraxinus uhdei.*

Forestry higher education facing social and economic changes. Zasada, M. (*Warsaw University of Life Sciences (SGGW), Poland; Michal.Zasada@wl.sggw.pl*), Małek, S. (*University of Agriculture in Cracow, Poland; rlmalek@cyf-kr.edu.pl*), Skorupski, M. (*Poznań University of Life Sciences, Poland; maskorup@up.poznan.pl*), Gruchała, A. (*Warsaw University of Life Sciences (SGGW); Arkadiusz.Gruchala@wl.sggw.pl*), Frankowicz, M. (*Jagiellonian University, Poland; marek.frankowicz@gmail.com*).

The last two decades have brought many legal, economic, and social changes that have led to a new situation for forestry. Globalization, demographics, economic crisis, global changes, and increased emphasis on nature conservation bring new challenges both for the forest sector and for forestry education. Now more than ever, higher education in forestry has to be based on deep and innovative scientific research, both basic and applied. At the same time, a trend of discontinuing programs that offer forestry degrees has been observed, along with the combining of agricultural and forestry universities and faculties with the more general "life sciences" institutions. The mismatch between graduates' skills and the demands of the contemporary, rapidly changing labor market is discussed. Current trends in higher education in Poland are presented. Entrance requirements for programs, the need to develop soft skills, the promotion of foreign language literacy, and mobility and the ability to work on international teams are addressed. These new capabilities are becoming as important as the in-depth knowledge and skills directly related to the major field of study.

Exclusion of low-income households from forestry management: a study on forestry specialized cooperatives in China. Zhu, R. (*National University of Singapore, Singapore; a0086261@nus.edu.sg*).

Existing literature on forest management has extensively examined factors that affect participation and collective action in decentralized forest management. Exclusion of the poor is generally considered to be a result of inefficient government regulation and the inherent heterogeneity of communities. However, few systematic studies have identified the factors that affect common elite capture in community-based forest management. The exclusion of low-income households is by no means a static story. To explicate circumstances that exacerbate or mitigate effects of exclusion, it is necessary to explore institutional conditions at national as well as local levels. Therefore, this research will highlight the multi-level institutional factors that influence the issue of exclusion, specifically in the Forestry Specialized Cooperatives (FSCs) in China. Even though the Chinese central government has praised FSCs as a crucial means of promoting farmers' interests and rights, there is growing criticism that FSCs are marginalizing low-income citizens. Building on the multi-level institutional perspective, the research will provide a multi-level theoretical framework to explain the causes of internal exclusion in FSCs. This issue is important because it focuses on the most marginalized people in China—the rural poor. It also contributes to the global experiences of decentralized forest management. This study will be one attempt to link the FSC experience to international debates on community-based forest management.

GENERAL POSTER SESSIONS

IUFRO Division 7: Forest Health

Natural occurrence and pathogenicity of *Metarhizium anisopliae* obtained from Peninsular Malaysia forest soils against *Atteva scidoxa* larvae. Ahmad, M. (*Forest Research Institute Malaysia; mohdfarid@frim.gov.my*).

Atteva sciodoxa is a major threat to plantations of the herbal plant *Eurycoma longifolia* in Peninsular Malaysia. Control of this pest is difficult as application of chemical pesticides is not encouraged in the plantations. In addition, *A. sciodoxa* larvae are robust because they can withstand high daytime temperatures, have few natural predators, and are present throughout the year. Thus, development of a biological control method using entomopathogens could be an alternative approach in controlling the pest infestations. Soil samples were collected from 25 natural forests in Peninsular Malaysia and the presence of *Metarhizium anisopliae* was evaluated via the Galleria bait method with modification. Of the 25 samples studied, 96% were positive for *M. anisopliae* regardless of soil texture, organic content, soil moisture, pH, and elevation. However, they were isolated more frequently from lowland dipterocarp forests than upland dipterocarp forests. Pathogenicity assessment conducted on 3–4 instar stages of *A. sciodoxa* larvae revealed that all the fungal isolates were relatively pathogenic. The average mortality recorded was 85.6% and it occurred within 4.5 days of inoculation. However, only four isolates, namely, FRIM874, FRIM875, FRIM587, and FRIM862, were highly pathogenic against the larvae with 100% mortality. These isolates have potential for further study in developing a mycoinsecticide against the insect pest.

Emerging insect pest and disease in *Cedrela odorata* plantations in Ghana. Apetorgbor, M. (*Council for Scientific and Industrial Research, Ghana; mapetorgbor57@gmail.com*), Bosu, P. (*Forestry Research Institute of Ghana, Ghana; paul_bosu@yahoo.com*), Roux, J. (*FABI-University of Pretoria, South Africa; jolanda.roux@fabi.up.ac.za*).

Large-scale planting of high value indigenous tree species in Ghana was unsuccessful as a result of insect pest and disease problems. These failures, together with the urgent need to establish plantations to meet demand in the face of decreasing timber from naturally managed forests, partly account for the widespread planting of Cedrela (*Cedrela odorata*) and other exotic species. Insect pest and disease outbreaks in tree plantations, which used to be generally low, have been reported to be increasing with expansion of plantations. The purpose of this study was to identify insect pests and diseases occurring in Cedrela plantations and evaluate management strategies. A field survey was undertaken in 2- to 4-yr-old-plantations in three ecological zones of Ghana, and root and stem samples were collected. Diseased trees were heavily infested with bark borers (*Apate* spp.), whose attack triggers the flow of brownish gum, resulting in dieback in the plantations. White mycelia were observed in cambial layers between the bark and wood of basal stems in the moist evergreen forest zone. Morphological observations and DNA sequence data indicated *Armillaria hemii* was the cause of the root rot. These insect pests and diseases inflicted serious economic losses of 82–89% on farmers' plantations. Sustainable integrated pest management strategies are discussed.

Diagnosis of forestry pests and diseases in Costa Rica. Arguedas, M. (*Instituto Tecnológico de Costa Rica, Costa Rica; marguedas@itcr.ac.cr*).

Costa Rica has been reported to have 75 000 ha of forest plantations, mainly of species such as *Tectona grandis, Gmelina arborea, Acacia mangium, Cupressus lusitanica, Alnus acuminate, Vochysia* spp., and *Cordia alliodora.* As the Payment for Environmental Services Program was implemented over the last decade, other forest species gained importance for propagation for protection and urban forests. Plantations of these species have been found to have economically significant phytosanitary problems. Since 1984, the Costa Rica Institute of Technology has been performing a national diagnosis of forest pests and diseases. A total of 594 insect species (75% of all pests and diseases diagnosed), 154 pathogens (19%), 32 vertebrates (4%), and 13 mistletoe species (2%) have been reported in 170 tree species. The main problems are: *Hyblaea puera* and various Chrysomelidae and Geometridae species in *Tectona grandis*; *Rifargia* spp. and *Caviria vinasia* in *Vochysia guatemalensis*; rust on foliage and twigs of *Puccinia cordiae, Melampsoridium alni, Olivea tectonae, Prospodium* spp., and *Uredo cupressicola*; shoot borers (*Hypsipyla grandella* and *Cosmopteryx* spp.) and the bark beetle *Scolytodes alni* in *Alnus acuminate*; and various Cerambycidae species and cankers (*Chrysoporte cubensis, Erythricium salmonicolor*, *Nectria* spp., and *Seiridiun cardinale*) on the stem of and vascular wilt (*Verticillium* sp.) in *Calophyllum brasiliense*.

Trophic interactions between vertebrate insectivores and a climate-driven expanding forest moth. Barbaro, L. (*National Institute for Agricultural Research (INRA), France; luc.barbaro@pierroton.inra.fr*), Battisti, A. (*University of Padova, Italy; andrea.battisti@unipd.it*), Charbonnier, Y. (*Institut National de la Recherche Agronomique, France; yohan.charbonnier@pierroton.inra.fr*), Dulaurent, A. (*Institut Polytechnique LaSalle, France; Anne-maimiti.DULAURENT@lasalle-beauvais.fr*), Jactel, H. (*Institut National de la Recherche Agronomique (INRA), France; herve.jactel@pierroton.inra.fr*).

The pine processionary moth (*Thaumetopoea pityocampa*) is a key defoliating moth of European pine forests, exhibiting cyclic outbreaks and currently expanding its range northwards and upwards in elevation due to warmer winters. Although vertebrate predators are known to influence insect outbreak dynamics, the evolution of predator-prey interactions under ongoing climate change is still subject to considerable uncertainty. For example, spatial and temporal mismatches between predators and prey may impede biocontrol efficiency. Here, the authors question the potential influence of insectivorous birds and bats on this climate-driven expanding moth, which displays many morphological and behavioural adaptations to avoid predation: eggs are protected by scales, late-instar larvae release urticating setae and hide during daytime in silk winter nests, pupae are buried in the soil and imagos emerge at night. The authors successively quantify numerical and functional responses of specialist birds, generalist birds, and generalist bats to *T. pityocampa* density for all life stages, i.e., eggs, late-instar larvae, pupae, and imagos. The authors suggest that sustaining long-term biological control of the pine processionary moth would require the maintenance of high functional diversity of vertebrate insectivores at the landscape scale, including both generalists and specialists.

Improving mass rearing techniques for *Cleruchoides noackae* (Hymenoptera: Mymaridae). Barbosa, L. (*EMBRAPA, Brazil; leonardo.r.barbosa@embrapa.br*), Beltramin, F. (*EMBRAPA Florestas, Brazil; fabiele_belt@yahoo.com.br*), Rodrigues, A. (*EMBRAPA, Brazil; aperufforodrigues@gmail.com*), Martinez, G. (*Instituto Nacional de Investigación Agropecuaria, Uruguay; gmartinez@tb.inia.org.uy*), Wilcken, C. (*São Paulo State University, Brazil; cwilcken@fca.unesp.br*).

The bronze bug, *Thaumastocoris peregrinus*, is an important pest affecting Eucalyptus plantations. The egg parasitoid *Cleruchoides noackae* was introduced in Brazil in 2012 for biological control of this pest. A mass rearing of *C. noackae* was established at EMBRAPA Florestas. This paper summarizes the main techniques developed to date in order to maximize the production of adult *C. noackae*. The use of eggs laid on towel paper strips increased the number of emerging parasitoids when compared to cutouts of Eucalyptus leaves. Host eggs 2 days old are preferred by *C. noackae* over 3- or 4-day-old ovipostures. Eggs can be stored at 5 ºC for 30 days after being parasitized without significant effects on parasitoid emergence; such storage is a convenient strategy. The mean parasitoid emergence varies significantly with the density of host eggs; an increase in the number of host eggs offered reduced the number of parasitoids that emerged. These improvements have played a significant role in the production of *C. noackae* that has made possible mass release of *C. noackae* in Brazil and the establishment of natural populations of the parasitoid, as recently confirmed.

Evaluation of mortality in natural stands of *Pinus oocarpa* in Nicaragua. Bauman, T., Eckhardt, L. (*Auburn University, USA; tab0032@auburn.edu; eckhalg@auburn.edu*), Menard, R., Ward, J. (*U.S. Forest Service, USA; rmenard@fs.fed.us; jward@fs.fed.us*), Sediles, A. (*Universidad Nacional Agraria, Nicaragua; albertosediles@yahoo.com*).

Evaluations were conducted to determine the cause of mortality in sapling pine stands in the Nueva Segovia region of Nicaragua. These stands were natural regeneration in areas that had been devastated by *Dendroctonus frontalis* 10 years earlier. Approximately 10–20% of individual stands were affected. Mortality of individual trees occurred within 6–12 months after symptoms were observed. Observed symptoms included chlorotic and wilting foliage, black stained and resinous tissue in the roots and butt that extended into the stem, and insect galleries and feeding areas. Root samples of symptomatic trees were collected and traps for insect vectors were established. Material from insect galleries was also collected to determine species of fungi present. Galleries of a larger scolytid beetle were observed and *D. approximatus* was found. *Ips* spp. were present in some of the trees but were considered secondary. The objectives of this project are to determine the cause of this mortality, identify the insect and fungal associations, and describe the disease syndrome.

***Ninus taeda* roots represent a suitable host substrate for developing *Hylastes* spp. of bark beetles in Alabama, USA.** Bauman, T. (*Auburn University, USA; tab0032@auburn.edu*), Matusick, G. (*The Nature Conservancy, USA; gmatusick@tnc.org*), Menard, R. (*U.S. Forest Service, USA; rmenard@fs.fed.us*), Zeng, Y., Eckhardt, L. (*Auburn University, USA; yzz0015@auburn.edu; eckhalg@auburn.edu*).

During an investigation into premature mortality in *Pinus taeda* stands in Alabama, *Hylastes salebrosus* and *H. tenuis* bark beetles were observed colonizing the roots of affected trees. To further understand the role of beetles in tree death, two primary lateral roots were selected for excavation from six trees in the stand. Root samples were taken from two trees with healthy green crowns, two trees with chlorotic and dying crowns, and two trees with red, dead crowns. *Hylastes* beetles were found to colonize the roots of dying and dead trees. Both larvae and pupae of *H. salebrosus* were identified in collected roots, providing direct evidence of beetle breeding within the roots of *P. taeda*. Adult beetles were rolled onto media and roots containing brood galleries were plated onto media to identify any fungi associated with these beetles. Of the beetles recovered, 47% were found to be transporting up to five species of ophiostomatoid fungi. The fungi were identified as *Leptographium terebrantis*, *L. procerum*, Grosmannia huntii, and *G. alacris*. In addition, one undescribed Ophiostoma species was isolated. These findings indicate dying and dead *P. taeda* roots provide suitable host material for *Hylastes* brood development

Paper mulberry invasion in Ghana. Bosu, P., Apetorgbor, M., Nkrumah, E., Bandoh, K. (*Council for Scientific and Industrial Research, Ghana; paul_bosu@yahoo.com; mapetorgbor57@gmail.com; enkrumah@csir-forig.org.gh; pbandoh@csir-forig.org.gh*).

Broussonetia papyrifera [family Moraceae] is a highly invasive woody perennial introduced to Ghana from its native Southeast Asia. Regeneration of the species after forest clearing occurs by stumps, root sprouting, and seedlings from the seed bank. A recent study to assess the impact of *B. papyrifera* invasion in forest and forest-savanna transition sites has increased our understanding of its invasive patterns. In a comparative assessment of species composition in invaded and uninvaded stands, relative percent cover of resident species/guilds that included indigenous broadleaved species and grasses was significantly lower in invaded plots. Seven months after *B. papyrifera* was experimentally removed from invaded plots, indigenous broadleaved species increased significantly in removal plots at the forest site. At the forest-savanna transition site, however, the increase in percent cover of indigenous species was not significantly different from control plots. These results led to the conclusion that *B. papyrifera* may favour indigenous species communities in the transition zone, whereas its removal is more likely to favour regeneration in a forest zone. Studies have been planned to determine whether paper mulberry invasion alters soil physical and chemical properties and whether its competitive ability is mediated through allelopathic effects.

An economic comparison of prevention strategies against forest pathogens. Brunette, M., Caurla, S. (*National Institute for Agricultural Research (INRA), France; marielle.brunette@nancy.inra.fr; sylvain.caurla@nancy.inra.fr*).

This paper analyses strategies for prevention of forest pathogenic risks from an economic perspective. A forest economics methodology was developed within a cost-benefit framework in order to compare existing treatments to prevent the invasion of three pathogens (*Hylobius abietis*, *Dothistroma septospora* and *Dothistroma pini*, and *Heterobasibion annosum*) in Landes forest, in the southwest of France. Results show that for *Hylobius abietis*, prevention, either through self-insurance (Foster solution) or self-protection (fallow), appears to be more cost-effective than taking no preventive steps. For *Dothistroma septospora* and *Dothistroma pini*, results indicate that the treatment analysed, i.e., self-protection (*Diathane paysage*), is never economically feasible for the forest owner because it induces a negative land expectation value (LEV). The authors computed the threshold

value of the treatment for which the LEV becomes positive and thus the treatment could be considered. This value is 45% lower than the current one. Finally, for *Heterobasibion annosum*, various self-protection activities were analysed, and local stump removal just after contamination is shown to always be more profitable than a systematic preventive treatment and that a fallow period at the end of rotation performs better than local stump removal if and only if the contamination occurs during the second thinning, when the forest is mature. Beyond the specifics of the case study, the paper proposes a methodology to analyse such problems.

Climatic change and insect outbreaks in Canada's boreal forests. Candau, J. (*Canadian Forest Service, Canada; Jean-Noel. Candau@nrcan.gc.ca*).

Insects are the world's most diverse class of organisms and as such they play a major role in the dynamics of most natural and human-managed ecosystems. Their impacts can be both positive and negative, direct and indirect, and generate positive or negative feedbacks, so understanding how climate change might influence insect impacts in forests is a daunting task. Insects as a whole represent the dominant natural disturbance factor in Canada's forests where, during outbreaks, host trees are often killed across extensive areas. This presentation considers how climate change might influence insect outbreak regimes in Canada's boreal forests. Also discussed are the direct and indirect effects of climate change on Canada's forest insects and the challenges associated with forecasting insect outbreak regimes in a changing environment.

Impact of soil moisture, humidity, and climatic conditions on Scots pine (*Pinus sylvestris* L.) damage in Lithuania. Čapkauskas, G., Žemaitis, P., Stakenas, V., Varnagiryte-Kabasinskiene, I. (*Lithuanian Research Centre for Agriculture and Forestry, Lithuania; gediminas.capkauskas@gmail.com; povilaszemaitis@gmail.com; v.stakenas@mi.lt Aleksandras Stulginskis university., Lithuania; i.varnagiryte@mi.lt*).

Increases in mean temperature, frequency of summer droughts, and dry episodes during periods of active growth of tree components have been discussed in recent decades as the primary climatic factors affecting forest health in Europe. The aim of this research was to investigate the correlation between forest health (main indicators: crown defoliation and frequency of biotic and abiotic tree damage) of Scots pine (*Pinus sylvestris* L.) stands, climatic factors (mean temperature and amount of precipitation) in forest site types with different humidity. Meteorological data from the network of meteorological stations and tree condition data from the Forest Monitoring (Level I) databases for the period 1991–2012 were analysed (3 000 of Scots pine trees annually). The De Marton dryness index was used in evaluation of the effect of drought on Scots pine health. The frequency of Scots pine damage was found to be significantly correlated with the climatic conditions. During the period analyzed, three different stages of mean annual temperature trend were revealed: decreasing (1991–1996), stable or no change (1997–2004), and increasing (2005–2010). Tree damage occurred more often during periods with higher mean temperature and longer periods of drought.

Report of *Chrysoporthe cubensis* Bruner Gryzenhout & M. J. Wingf. in plantations of *Eucalyptus pellita* in the Colombian Orinoquia region. Chocontá, A., Pinzon, O. (*Universidad Distrital Francisco Jose de Caldas, Colombia; victornieto@conif.org.co, Colombia; anagibeth73@hotmail.com; oppinzon78@hotmail.com*), Nieto, V. (*Corporación Nacional de Investigación y Fomento Forestal (CONIF), Colombia; victornieto@conif.org.co*).

Eucalyptus canker is one of the most limiting diseases for *Eucalyptus* cultivation worldwide. In order to characterize the causal agent of the canker observed in commercial stands of *E. pellita* in the Casanare department of Colombia, samples were collected from bark of diseased trees for further study in the laboratory. Several isolates of the fungus were obtained on malt extract agar medium incubated at a constant temperature of 27 °C. The fungus was identified as *Chrysoporthe cubensis* Brunes Gryzenhout & M. J. Wingf. The strains obtained were preserved using the techniques of cryopreservation and lyophilization at the microbiology ceparium of the Universidad Distrital for further molecular characterization. Canker symptoms were observed in the field from the base of the tree to 165 cm high in trees from 7 months to 3 yr old. Although not considered an epidemic attack, this is the first record of *C. cubensis* in commercial plantations of *E. pellita*. Therefore, efforts are needed in breeding programs for *E. pellita* because this species is considered to have high economic potential in the region.

New records of insects associated with seedlings of some forest trees in Sabah, Malaysia. Chung, Y., Richard M., Ong, R., Kuina, K., Eyen, K., Hastie, A. (*Sabah Forestry Department, Malaysia; arthur.chung@sabah.gov.my; richard.majapun@sabah.gov.my; robert.ong@sabah.gov.my; Kuina.Kimjus@sabah.gov.my; eyen.khoo@sabah.gov.my; Alexander.YukLoongHastie@sabah.gov.my*).

Insects can cause considerable damage to their host trees, which may adversely affect tree health and growth. Hence, it is important that documentation of insects associated with various forest trees be continued to provide baseline information from which insect pest profiles of each individual economic tree species can then be compiled. This paper presents some of the new records of insects associated with some of the forest trees in Sabah, Malaysia. The new host plant records include commercial timber trees (*Shorea johorensis, S. ovalis, Vatica rassak*, and *Hopea nutans*), forest trees for restoration of riparian areas (*Nauclea subdita* and *Mitragyna speciosa*), peat swamp forest species (*Gonystylus bancanus*), Bornean endemic dipterocarp (*Shorea symingtonii*), and the Bornean ironwood (*Eusideroxylon zwageri*). All these were recorded at the nursery of the Forest Research Centre, Sepilok, in Sandakan. Life cycle of the insects was monitored and identification was based on the emerged adults.

CONFT-IR spectroscopy identifies coast live oak resistant to *Phytophthora ramorum* before infection. Conrad, A., Rodriguez-Saona, L. (*Ohio State University, USA; conrad.245@osu.edu; rodriguez-saona.1@osu.edu*), McPherson, B., Wood, D. (*University of California, USA; bam23@berkeley.edu; bigwood@berkeley.edu*), Bonello, P. (*Ohio State University, USA; bonello.2@osu.edu*).

Sudden oak death, caused by the introduced oomycete *Phytophthora ramorum,* can be deadly for coast live oak (*Quercus agrifolia*); nonetheless, naturally resistant trees, i.e. those that survive infection, are known to occur in nature. However, identifying resistant trees based on survival may take up to 7–10 years, making management of affected forests extremely challenging

and unpredictable. In this study, Fourier transform infrared (FT-IR) spectroscopy was used to analyze methanol extracts from healthy coast live oak phloem tissue. After tissue collection, trees were inoculated with *P. ramorum* and symptom development was monitored annually in order to classify trees as resistant or susceptible. Using soft independent modeling of class analogy (SIMCA) and partial least squares regression (PLSR), the authors found that spectral frequencies from FT-IR analysis could be used to both discriminate between resistant and susceptible trees, and corroborate qualitative and quantitative analyses of constitutive phenolics using HPLC. This is the first report of the use of FT-IR spectroscopy to identify coast live oak resistant to *P. ramorum* before infection. FT-IR may be a useful tool not only for the management of urban and natural forests affected by sudden oak death, but also for the management of other emerging forest pests and pathogens.

Critical thermal limits for the southern spread of the gypsy moth. Dattelbaum, K. (*Virginia Commonwealth University, USA; kdattelbaum@vcu.edu*), Parry, D. (*State University of New York, USA; dparry@esf.edu*), Tobin, P. (*U.S. Forest Service, USA; ptobin@fs.fed.us*), Agosta, S., Johnson, D. (*Virginia Commonwealth University, USA; sagosta@vcu.edu; dmjohnson@vcu.edu*).

Determining the factors that drive the extent of spatial spread in invasive species is fundamental for mitigating the negative impacts of damaging insect pests to forest ecosystems. For invasive species, climate change could open new habitats to invasion or impose environmental barriers to further spread. The gypsy moth (*Lymantria dispar*) is an invasive folivore in North American hardwood forests and represents one of the best documented biological invasions in the world. Over twenty years of trapping data has revealed extremely dynamic spread rates, with some regions experiencing range expansion while the invasion front in other regions, such as the southeast, is static or contracting. Our work tests the lethal and sublethal effects of maximum temperatures on gypsy moth development and life history traits. We measure the potential for adaptation to novel climates, as well as inherent plastic responses, by testing populations from across the invasion front. This biophysical information will be incorporated into distribution models to explicitly link functional traits with both present and projected environments. Incorporating physiological limits into species distribution studies establishes the mechanistic relationship between climate and species' tolerances and results in more robust predictive models.

Patterns and processes affecting stem borers in subtropical eucalypt plantations. Debuse, V. (*Queensland Department of Agriculture, Fisheries and Forestry, Australia & University of the Sunshine Coast, Australia; vdebuse@usc.edu.au*), Lawson, S. (*Queensland Department of Agriculture, Fisheries and Forestry; Simon.Lawson@daff.qld.gov.au*); Smith, T. (*Queensland Department of Agriculture, Fisheries and Forestry, Australia & University of the Sunshine Coast, Australia; tim.smith@daff.qld.gov.au*), Carnegie, A. (*University of the Sunshine Coast, Australia; angus.carnegie@fcnsw.com.au*).

Longicorn beetles (Coleoptera: Cerambycidae) and cossid moths (Lepidoptera: Cossidae) are insect borers that are major global pests of eucalypt plantations. In Australia, damage from borers and associated fungal invasion can reduce sawlog timber value by up to 90%. Despite this, there has been little research to date on determining the major predictors of the incidence or severity of borer attack. The authors examined site- and landscape-scale drivers of borer damage from both insect families in two plantation species, *Corymbia citriodora* subsp. *variegata* (CCV) and *Eucalyptus grandis*, in Queensland and New South Wales, Australia. Twenty CCV and 19 *E. grandis* plantations were assessed for incidence, severity, and bole height of borer attacks, representing 4 200 CCV and 3 990 *E. grandis* trees in total. Landscape and site predictors were collected for each site through field surveys and from databases and analysed with the borer data to determine the relative importance of each variable in predicting the extent of borer attack. The authors demonstrate the extent to which the risk of borer attack can be mitigated by the grower through improved management protocols and discuss the relative importance of other extrinsic influences that are beyond industry control.

***Phytophthora plurivora*, a new species causing collar rot on *Alnus glutinosa* in Spain.** Diez-Casero, J., Martín-García, J., Martínez-Álvarez, P., Haque, M., Lomba, J. (*University of Valladolid, Spain; jdcasero@pvs.uva.es; jorgemg@pvs.uva.es; pmtnez@pvs.uva.es; mhaque@pvs.uva.es; josemalomba@gmail.com*).

In a survey of *Phytophthora* associated with alder mortality in Castilla y León, Spain, several isolates of a new *Phytophthora* sp. were consistently recovered from necrotic bark of the collar and lower stem of *Alnus glutinosa* by direct plating onto a selective agar medium. The *Phytophthora* species displayed a radiate and slightly chrysanthemum-like growth pattern on V8 juice agar. Mycelial growth of the isolates was optimal at 25 °C; no growth was observed at 32 °C. The isolates were homothallic and produced smooth-walled spherical (very rarely elongated) oogonia with paragynous antheridia, and both plerotic and aplerotic golden brown oospores on V8 juice agar. In non-sterile soil extract, the isolates produced sporangia which were non-caducous, semi-papillate, mainly ovoid and obpyriform, and obovoid to limoniform but sometimes distorted with two apices. The isolates were highly pathogenic to the seedlings of *A. glutinosa* and resulted in wilting and mortality following the under-bark inoculation. The ITS region of the rDNA was amplified, sequenced, and compared with the reference sequence of *Phytophthora plurivora*, showing 100% identity with it and confirming its morphological and physiological identification. This is the first record of *P. plurivora* affecting *A. glutinosa* in Spain.

Status of forest tree diseases in Turkey. Dogmus-Lehtijarvi, T. (*Çankırı Karatekin University, Turkey; tugbadogmus@sdu.edu.tr*), Lehtijarvi, A. (*Bursa Technical University, Turkey; asko.lehtijarvi@btu.edu.tr*), Aday Kaya, G., Oskay, F. (*Çankırı Karatekin University, Turkey; guldenaday@sdu.edu.tr; fundaoskay@sdu.edu.tr*).

Forests in Turkey occupy 21.7 million ha. As a result of afforestation and rehabilitation efforts the total area of forest is increasing while the area of degraded forests is decreasing. Biotic and abiotic stress factors such as disease, drought, windstorms, and wildfire periodically affect forests or specific tree species, leaving dead or weakened trees. The effects of these stresses may be manifested locally or over a larger area, but they do not cause species extinction. Mycological studies of Turkish forests were first started in the 19th century in Istanbul, and this tradition was continued during the 1960s. The first ecological and forest pathological studies were published in the late 1970s. During the last 10–20 years there has been a considerable increase in the number of mycological studies, especially in floristic surveys, which have been carried out in different forest ecosystems. This review aims to summarize the current knowledge about most common forest tree diseases reported in Turkey. Currently, Annosum root rot, European pear rust on juniper, Armillaria root disease, *Phytophthora* dieback on oaks, red band needle blight, Dutch elm disease, Diplodia shoot blight, box blight, chestnut blight, and stem rots are considered the most important forest diseases.

To know a bark beetle: ecophysiological implications for mathematical modeling of bark beetle population dynamics. Dolezal, P., Miklas, B., Bartosova, E., Davidkova, M., Okrouhlik, J. (*University of South Bohemia, Czech Republic; dolezal@entu.cas.cz; b.miklas@centrum.cz; bartyk@seznam.cz); marketadavidkova@seznam.cz; okrouhl@entu.cas.cz*).

In the last three decades, predictive models of bark beetle population dynamics shifted from simple linear models to complex ones that use numerous ecophysiological variables. The authors summarize results of 17 years of research on bark beetle physiology, which not only explain phenomena commonly observed by foresters, but also ensure precise prediction of bark beetle population dynamics in a globally changing environment. Key studied aspects included changes in bark beetle physiology during late summer (related to imaginal diapause), overwintering, flight ability, energy status, reproductive biology (sister-broods), and influence of temperature and day length on voltinism. First, the authors identified the critical day length for diapause induction and temperature threshold preventing beetles from entering diapause regardless of day length. The authors' recent studies describe changes in chemical composition of bark beetles (cold resistance, lipid and carbohydrate reserves), dispersal abilities, and estimated energy used during flight. Finally, a large-scale field study on sister-brood development and comparison of recent and historical data from the 1950s and 1960s has helped to identify the influence of temperature on reemergence rate, reproductive success, and gonadal physiology. Inclusion of all these aspects led to a PHENIPS-based model which increases the efficiency of protective measures against bark beetles.

Two new ophiostomatoid species isolated from soil on snouts of feral hogs damaging pine roots in Georgia, USA. Eckhardt, L., Ditchkoff, S. (*Auburn University, USA; eckhalg@auburn.edu; ditchss@auburn.edu*), Duong, T., de Beer, W., Wingfield, M. (*FABI-University of Pretoria, South Africa; Tuan.Duong@fabi.up.ac.za; wilhelm.debeer@fabi.up.ac.za*, *Mike.Wingfield@up.ac.za*).

The role of wild pigs in dispersing pathogenic fungi during rooting activity is poorly understood in terms of forest pathology. In this study to consider this question, fungal isolates were obtained from soil on the snouts of feral hogs trapped in *Pinus palustris* and *P. taeda* stands in Fort Benning, Georgia. Micromorphology and DNA sequences of the ITS, elongation factor, and beta-tubulin gene regions were used to identify the fungi. Three ophiostomatoid species were identified, of which only one**,** *Ophiostoma sparsiannulatum*, was of a known species**.** The remaining two species will respectively be described as novel taxa in *Ophiostoma sensu lato* and the *Leptographium procerum* species complex. In addition to the discovery of new fungal species, this study shows that wild pigs may reduce tree vigor by causing wounds for soil-borne or insect-vectored pathogen infection, predisposing trees to bark beetle attack and perhaps incidentally introducing phytopathogens during rooting activity.

Winter moth: biological control and population dynamics in the northeastern United States. Elkinton, J., Boettner, G. (*University of Massachusetts, USA; elkinton@ent.umass.edu; boettner@psis.umass.edu*).

The winter moth (*Operophtera brumata*)*,* a leaf-feeding geometrid native to Europe, has recently invaded eastern New England (USA) and is causing widespread defoliation. Previous invasions by this species in Nova Scotia and British Columbia have been suppressed by the introduction of two parasitoids from Europe, the tachinid *Cyzenis albicans* and the ichneumonid, *Agrypon flaveolatum*. As a result of these introductions, low-density populations of winter moth now persist indefinitely in these regions similar to those that exist in Europe. Over the past 8 years the authors have introduced *C. albicans* at 22 locations in Massachusetts, Rhode Island, and Maine. These efforts are focused on *C. albicans* because it specializes on winter moth and it is thought to be the agent primarily responsible for the decline of winter moth densities in Canada. As of this year the authors have established *C. albicans* at seven sites and parasitism levels have been increasing steadily at these sites. The authors have also documented yearly changes of density and survival of winter moth life stages at these sites so that they can explain the yearly fluctuations of density that they have observed and the impact of *C. albicans* with respect to the other sources of mortality in this system.

Evidence of widespread ozone-induced visible injury on plants in Beijing. Feng, Z. (*Chinese Academy of Sciences, China; zhzhfeng201@hotmail.com*), Calatayud, V. (*Fundación CEAM, Spain; calatayud_viclor@gva.es*), Wan, W., Sun, J. (*Chinese Academy of Sciences, China; wan.wx1972@126.com; sunjingsong1@163.com*).

One of the most evident ways to document ozone effects on vegetation is the assessment of ozone-induced visible injury in leaves of sensitive species. Despite the high ozone levels measured in China and in Beijing in particular, impacts on vegetation have scarcely been reported. Several field surveys were conducted in July and August 2013 in the main parks, forests, and agricultural areas of Beijing. Ambient ozone levels were high enough to induce foliar symptoms in more than 25 different species. Ozone symptoms were more frequent in rural areas and mountains in northern Beijing, and less frequent in city gardens. Injury to different types of beans, belonging to different genera, was common and widespread in all the areas. Other affected crops were watermelon, grape vine, and several species of gourds. Among native species, visible injury was common in ailanthus, and it was also observed in pines, ash species, and climbing shrubs such as *Ampelopsis humulifolia*. Ornamental plants such as the black locust (*Robinia pseudoacacia*), the rose of Sharon (*Hibiscus syriacus*), and Japanese morning glory (*Ipomoea nil*) also exhibited ozone symptoms in different Beijing areas.

Photosynthesis and growth response of *Metasequoia glyptostroboides* seedlings to elevated ozone. Feng, Z., Zhang, W., Wang, X. (*Chinese Academy of Sciences, China; zhzhfeng201@hotmail.com; zwwno_1@163.com; wangxk@rcees.ac.cn*).

High ambient ozone (O_3) concentration has frequently been observed in southeast China, especially in the developed subtropical region of the Yangtze River Delta. *Metasequoia glyptostroboides* (Hu and Cheng) is a rare deciduous "living fossil" conifer species widely distributed in subtropical regions not only as a natural forest stand but also an important greening species planted in southern cities of China. In this study, *M. glyptostroboides* was exposed to ambient air (NF) and elevated ozone (E-O_3; NF+60 ppb) for 2 years in open-top chambers, in order to determine whether rising O_3 concentration in the future might negatively affect the growth of this rare species. Results indicated that E-O_3 significantly reduced photosynthetic pigment contents, net photosynthetic rate, maximum carboxylation capacity, and electron transport in both 2009 and 2010. In contrast, E-O_3 only

significantly reduced stomatal conductance (g_s) in 2009; it did not change g_s in 2010. E-O_3 inhibited whole-plant carbon accumulation and distribution over two growing seasons, and significantly decreased leaf dry mass per area and the increments of branch number. The data suggested that the net photosynthetic rate of *M. glyptostroboides* has been significantly decreased by E-O_3 mainly due to reduced carboxylation capacity and electron transport.

Effects of elevated ozone on the injury, growth, and photosynthesis of 10 woody species widespread in Beijing. Feng, Z., Zhang, Y. (*Chinese Academy of Sciences, China; zhzhfeng201@hotmail.com; 373862305@qq.com*), Yuan, X. (*Beijing Technology and Business University, China; windy_yuan0904@126.com*), Calatayud, V. (*Fundación CEAM, Spain; calatayud_viclor@gva.es*), Yang, T. (*Beijing Technology and Business University, China; sdjdytt@126.com*), Gao, F.

Tropospheric ozone (O_3) is considered one of the most critical air pollutants for forests due to its detrimental effects on carbon sequestration and forest health. Very little is known about the effects of O_3 on forest species from Asia. Due to rapid urbanization in China, ambient O_3 concentrations in some cities reach phytotoxic levels, causing visible injury in many herbs and woody species. The study of responses to O_3 of representative woody species from suburbs and cities is therefore important in order to assess effects on carbon sequestration in the urban forest ecosystem. For this study, 1-year-old seedlings were selected from 10 woody species: *Acer truncatum, Ailanthus altissima, Fraxinus chinensis, Hibiscus syriacus, Koelreuteria paniculata, Platanus orientalis, Prunus davidiana, Robinia pseudoacacia, Sophora aureus,* and *Ulmus pumila*. Plants were exposed in open-top chambers to five O_3 treatments: non-filter ambient air (NF), NF+20 ppb, NF+40 ppb, NF+60 ppb, and NF+80 ppb for 4.5 months. During fumigation, visible injury evolution was assessed every week, and growth and chlorophyll content were measured each month. Foliar photosynthesis was measured in August and October. At the end of fumigation, all plants were harvested and separated into root, stem, leaves, and branches. These results will be presented.

Variation in susceptibility of native Scottish Scots pine populations to infection by *Dothistroma septosporum*. Fraser, S. (*University of Aberdeen, UK; sfraser@abdn.ac.uk*), Brown, A. (*Forest Research UK, UK; anna.brown@forestry.gsi.gov.uk*), Woodward, S. (*University of Aberdeen, UK; s.woodward@abdn.ac.uk*).

Artificial inoculations and field infections were used to determine the relative susceptibility of six Scottish *Pinus sylvestris* populations to infection and damage by the needle blight pathogen *Dothistroma septosporum*. Field infections were monitored for 2 years (2012 and 2013) on trees planted at two sites, Culbin in north-east Scotland and Torrs Warren in south-west Scotland. In field experiments, site, year, and population significantly affected disease severity. There was also a significant interaction between site and population. In both years the greater disease severity was seen at Torrs Warren, the site with the higher level of summer precipitation. At both sites, disease severity was significantly greater in 2012, a year with an abnormally wet summer. Population had a significant effect on disease severity in 2012, when overall disease levels were high, but different patterns of relative susceptibility were seen at the two sites. At Culbin, trees from Benn Eighe showed the most infection; however, at Torrs Warren, plants sourced from Glen Carrich, Glen Loyne, and Abernethy were most severely affected. Results of the artificial inoculations were similar to those seen at Torrs Warren in 2012, the greatest disease severity being observed on plants from Glen Cannich and Glen Loyne.

Socioeconomic assessment of the impact of the red palm mite on the Nariva Swamp of Trinidad and Tobago. Garcia, M., Seepersad, G. (*University of the West Indies, Trinidad and Tobago; marc.garcia@sta.uwi.edu; govind.seepersad@uwi.sta.edu*), Bossenbroek, J. (*University of Toledo, USA; jmbossen@gmail.com*).

In 2006, the red palm mite (*Raoiella indica* Hirst) was marked as officially established in Trinidad and Tobago. The mite is a great threat to terrestrial biodiversity and is of particular concern in palm populations. Locally, the coconut palm (*Cocos nucifera*) has been the most affected. The Nariva Swamp in Trinidad, a designated Ramsar site, is home to a large population of palms. The impact of the red palm mite on this ecosystem is both direct and indirect. Its direct impact includes declining yields of coconuts and resulting increased market prices. Indirect impacts of this invasion include the loss of non-market ecosystem goods and services, such aesthetic value, biodiversity, and demand for recreational services. This study was aimed at estimating the indirect costs of invasion by the mite. Two methods were used to estimate its non-market impacts: contingent valuation and travel cost method of valuation. These data were collected through questionnaires, both on and off the study site. Most of the population was unaware of the mite and its effect but willing to pay to conserve the swamp's biodiversity. The authors suggest increased spending on awareness campaigns and removal efforts.

Population genetics reveals the origin of the *Coryphodema tristis* host expansion to *Eucalyptus nitens* in South Africa. Garnas, J., Degefu, D., Hurley, B., Wingfield, M., Slippers, B. (*FABI-University of Pretoria, South Africa; jeff.garnas@fabi.up.ac.za; dawit.degefu@fabi.up.ac.za; brett.hurley@up.ac.za, mike.wingfield@fabi.up.ac.za; Bernard.Slippers@fabi.up.ac.za*).

Emerging pests resulting from novel host associations between native pests and nonnative, commercially propagated trees represent a growing threat to global plantation forestry. Population genetics offers opportunities to better understand the patterns and processes linked to host use and range expansion. The source of the *Coryphodema tristis* (Lepidoptera:Cossidae) infestation of *Eucalyptus nitens* was investigated using mitochondrial cytochrome oxidase I (COI) sequence and amplified fragment length polymorphism (AFLP) data. Individuals of *C. tristis* collected from *E. nitens* plantations in Mpumalanga and *Vitis vinifera* in the Western Cape were analyzed together with museum specimens (COI only) from across South Africa. Fourteen COI haplotypes were obtained from 135 sequenced individuals, including two from contemporary *E. nitens* populations that showed high sequence similarity to a dominant haplotype collected throughout South Africa. AFLP analyses revealed minimal genetic diversity from samples on *E. nitens* with no structure among seven subpopulations spanning 90 km. Samples from *V. vinifera* were clearly distinct based on AFLP markers and COI. Results suggest that the infestation of *E. nitens* reflects recent movement from local populations, and that such events of host range expansion are rare. Host expansion onto Eucalyptus was independent of the colonization of grapevine in South Africa.

Impacts of variation in resource quality for larvae of the European woodwasp (*Sirex noctilio*) in South African *Pinus patula* plantations. Garnas, J., Termer, K., Hurley, B. (*FABI-University of Pretoria, South Africa; jeff.garnas@fabi.up.ac.za; katie.termer@fabi.up.ac.za; brett.hurley@up.ac.za*).

Variation in resource quality can influence oviposition choice, growth and survival, and ultimately population dynamics. The authors examined biotic and abiotic determinants of body size and sex ratio in *Sirex noctilio,* the globally invasive European pine woodwasp. Sex ratio has been observed to be highly male biased (>10:1) with female adult body size varying up to fourfold. Careful dissections of *S. noctilio*-infested logs collected at three time points during the larval developmental period were examined to understand how natural variation in factors hypothesized to correlate with resource quality may influence age and gender-specific larval growth and survival. Specifically, the authors investigated the role of wood moisture, tree section, larval density, sapstain abundance, and density of co-occurring insects on larval growth rate, survival, and resource use efficiency. Preliminary analyses indicate that larval mass is uniformly low at high larval densities, consistent with intraspecific competition. Growth rate increased as moisture increased, and male bias decreased. Effects on sex ratio appear to result from female oviposition choice as larval mortality was low. Larval resource use efficiency does not appear to be influenced by any of the factors considered. These findings form part of a more comprehensive understanding of resource quality from the perspective of *Sirex* larvae.

Linking phylogeographic history, niche divergence, and biological invasion risks: the case of North American *Dendroctonus* bark beetles. Godefroid, M., Rasplus, J., Rossi, J. (*National Institute for Agricultural Research (INRA), France; martin.godefroid@supagro.inra.fr; rasplus@supagro.inra.fr; jean-pierre.rossi@supagro.inra.fr*).

Species often display geographically structured intra-specific diversity resulting from past geologic and climatic events. Such phylogeographic histories may—or may not—have led to actual intra-specific niche divergences. Species distribution models (SDMs) depict the realized niche by linking species occurrences to environmental descriptors and are widely used to assess the risk of biological invasion. However, these SDMs are usually constructed at the species level without considering the potential differences between phylogeographic lineages. In the present work, the authors investigate how much their estimation of risk changes as the phylogeographic structures are accounted for while elaborating the SDMs. They tackle the question at a continental scale and consider five bark beetle species of the genus *Dendroctonus* which are among the most destructive organisms of North and Central American conifer forests. The focus is on their potential distribution in Europe and the associated risk. Results reveal that distinct phylogeographic lineages correspond to partially non-overlapping potential distributions in Europe. As a result, species-level niche models generally underestimate the potential range of *Dendroctonus* species in Europe. The authors conclude that risk assessment should rely upon SDMs incorporating phylogeographic structures whenever possible.

Updated list of Scolytid species occurring in commercial tree plantations in Uruguay. Gómez, D., Martinez, G. (*Instituto Nacional de Investigación Agropecuaria, Uruguay; dgomez@tb.inia.org.uy; gmartinez@tb.inia.org.uy*).

Commercialization of wood packing and plant materials, together with climate change, has led to an increased dispersion of pests and diseases worldwide, causing the colonization of new areas by bark and ambrosia beetles. In this context, it becomes necessary to work toward identifying new invasive species of scolytids. A dramatic increase in tree plantations began in Uruguay in the 1990s after a new forestry law went into force in the country, leading to more than 1 million ha forested with exotic trees (mostly *Eucalyptus* spp. and *Pinus* spp.) to date. In December 2009, after a severe drought episode, high mortality was recorded on pine tree stands during the first economically significant outbreak of bark beetles recorded in the country. Here the authors present an updated list of bark and ambrosia beetles recorded in commercial tree plantations in Uruguay, after 3 years of surveying. Bark and ambrosia beetles are part of the fauna commonly occurring in pine tree and eucalyptus plantations in Uruguay. Beetle species mainly belong to Dryocoetini, Ipini, Hylesinini, and Xyleborini.

Modeling stomatal ozone deposition in Mediterranean annual pastures using a multilayer-multispecies model. González-Fernández, I., Calvete-Sogo, H. (*Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT), Spain; ignacio.gonzalez@ciemat.es; hector.calvete@ciemat.es*), Büker, P., Briolat, A. (*University of York, UK; patrick.bueker@york.ac.uk; alan.briolat@york.ac.uk*), Elvira, S., Sanz, J. (*Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT), Spain; susana.elvira@ciemat.es; j.sanz@ciemat.es*), Emberson, L., Bermejo, V., Alonso del Amo, R.

Risk assessment of ozone effects on vegetation within the framework of the UNECE Convention on Long-range Transboundary Air Pollution (CLRTAP) is increasingly being based on modeled stomatal ozone deposition. Current models used to calculate ozone deposition fluxes represent the vegetation surface as a big leaf placed at the top of the canopy. However, this approach presents some limitations when used in species-rich plant communities with complex canopies like those of pastures. Species coexisting in the pasture have different gas exchange rates and sensitivity to ozone, affecting the deposition of ozone to individual components and its potential effects for sensitive species. A multilayer-multispecies model designed at the Stockholm Environment Institute, University of York, based on the existing deposition of ozone for stomatal exchange (DO_3SE) model used within the CLRTAP, has been parameterized using a 3-year-long database of meteorological variables, ozone concentration, and pasture physiological measurements on a Mediterranean annual pasture in Spain. Ozone fluxes were also calculated using the same approach for an ozone fumigation experiment in open-top chambers aiming at relating ozone stomatal fluxes to effects observed in the experiments. The ultimate goal of this study is deriving improved methodologies and novel ozone critical levels useful for risk assessment.

Characterizing Great Basin bristlecone pine tree chemistry. Gray, C., Jenkins, M. (*Utah State University, USA; curtis.gray@aggiemail.usu.edu; mike.jenkins@usu.edu*), Runyon, J. (*U.S. Forest Service, USA; jrunyon@fs.fed.us*).

Great Basin bristlecone pine (GBBP) typically co-occur with other similar pine species in the same ecological niche, such as Limber pine. Limber pine may be infested with mountain pine beetle (*Dendroctonus ponderosae* Hopkins), yet pine beetle has not been observed to infest GBBP. The authors hypothesize that the attraction of beetles could be due to differences in monoterpenes

between the two species. Terpenes are the main constituents of plant essential oils and resins and include all chemically modified forms such as terpenoids. Terpenes have a wide array of uses both ecologically and commercially and are known to play important roles in plant defenses against insect herbivory. Tree chemistry from temporal and spatial gradients at two sites in Nevada, USA, were quantified and compared at 2-hr increments once per month throughout summer 2013. Results revealed peaks in certain airborne volatile terpene compounds emitted from the trees needles. Preliminary analysis of airborne terpenes showed the presence of beta-myrcene, 3-carene, and beta-phellandrene in Limber pine, which previous studies have shown may be bark beetle attractants. These terpenes were all absent in the sampled GBBP.

Biotic and abiotic factors associated with large-scale die-off of a Eucalyptus clone in Zululand, South Africa. Greyling, I. (*FABI-University of Pretoria, South Africa; izette.greyling@fabi.up.ac.za*), van den Berg, G., Harrison, I., da Costa, D. Pienaar, B. (*Mondi, South Africa; gert.vandenberg@mondigroup.co.za; ian.harrison@mondigroup.co.za; dean.dacosta@mondigroup.co.za; ben.pienaar@mondigroup.co.za*), Mphahlele, M., de Beer, W., Wingfield, M., Roux, J.

Large-scale death of a single plantation-grown *Eucalyptus grandis x urophylla* clone was first reported in 2010 from the Zululand region in South Africa. Mortality occurred in patches that expanded rapidly, with up to 90% mortality reported in some areas. Sites on which the die-off has occurred differ across age and site classification classes. Prior to tree death, symptoms include foliage yellowing and death, internal staining of the vascular tissue, presence of ambrosia beetle tunnels, or a combination thereof. Eight different species of ambrosia beetles have been identified and various isolation techniques have been used to identify potential pathogens that they might carry. Various fungi and bacteria have also been isolated from dying trees, where all tree parts have been thoroughly considered. Despite intensive sampling and investigation, no clear cause of the mortality has been found. For the present, there are indications are that mortality is due to a complex interaction between biotic and abiotic factors. The fact that this problem has occurred on only one of many clones cultivated is intriguing and emphasises how little is known regarding the long-term health prospects for intensively propagated *Eucalyptus* clonal hybrids.

The role of drought and stand density in Jeffrey pine susceptibility to the Jeffrey pine beetle. Grulke, N., Graves, A., Seybold, S. (*U.S. Forest Service, USA; ngrulke@fs.fed.us, adgraves@fs.fed.us, sjseybold59@gmail.com*).

Drought and stand density are cited repeatedly as the primary causes of bark beetle outbreaks. However, the level of physiological drought stress and competition experienced is typically inadequately defined and measured. This research tested the roles of physiological drought stress and stand density in Jeffery pine (*Pinus Jeffreyi*) in five national forests over 3 years along an 85-km north-south latitudinal gradient on the eastern slope of the Sierra Nevada and Transverse Range (USA). Metrics used for competition were stand density (standard) and distance to nearest neighbor (con- and interspecific). Metrics for drought stress included needle and phloem water potential (pre-dawn and noon total, osmoticum, turgor water potential). In addition, resin quality and resin exudation rates were evaluated in the context of attacks by Jeffrey pine beetle (*Dendroctonus jeffreyi*). Physiological drought stress of needles was correlated with bole phloem turgor potential and with attack by *D. jeffreyi* and woodborers, but inversely correlated with resin flow rates. At all sites, tree drought stress was correlated with low percentage of annual average precipitation, but was greater in dense stands only at the northernmost site. Overall, attacked Jeffrey pines were closer to another single tree (i.e., higher tree-tree competition), but had fewer trees within their spheres of influence (i.e., lower density stands).

A mobile application and citizen science to monitor incidence and severity of Marri *Quambalaria coyrecup* cankers in Australia. Hardy, G., Marbus, C., Burgess, T., Paap, T. (*Murdoch University, Australia; g.hardy@murdoch.edu.au; c.marbus@murdoch.edu.au; t.burgess@murdoch.edu.au; t.paap@murdoch.edu.au*).

The incidence and severity of cankers caused by *Quambalaria coyrecup* in marri (*Corymbia calophylla*) have increased significantly in southwestern Australia since the early 1990s. Marri is an iconic overstorey forest tree across a number of forest ecosystems. It is a major food source, habitat tree, and refugium for numerous fauna, including the endangered Carnaby's cockatoo (*Calyptorhynchus latirostris*), as well as a "staple species" for apiarists. Consequently, the impact of the pathogen on marri is causing widespread concern across the community for many reasons. The authors have developed an application that works across mobile platforms (e.g., IPhone and Android) that is being used by interested members of the public, local government agencies, foresters, and scientists to capture location (GPS), incidence, and severity of cankers on trees, and upload photographs and other site information to a central server. The "Marri App" also informs users on what a canker looks like at different stages of development. Importantly, it also provides information on how to establish and monitor trials including fungicide and other treatment trials that will be statistically robust and informative for scientific purposes. The importance and power of the "Marri App" for information dissemination, community engagement, and citizen science will be discussed.

Host colonization behavior of the walnut twig beetle, *Pityophthorus juglandis* (Coleoptera: Scolytidae): implications for the worldwide cultivation of walnut trees. Hishinuma, S., Flint, M., Bostock, R. (*University of California, USA; chlorinated@gmail.com; mlflint@ucdavis.edu; rmbostock@ucdavis.edu*), Seybold, S. (*U.S. Forest Service, USA; sjseybold59@gmail.com*).

Thousand cankers disease of walnut (*Juglans* spp.) is caused by the fungal pathogen *Geosmithia morbida*, which is vectored by the walnut twig beetle (*Pityophthorus juglandis*; WTB). The disease has been reported from walnut species throughout the United States and threatens walnut trees worldwide. Disease severity appears to be governed by susceptibility of trees to attack by WTB or to canker formation following *G. morbida* infection. The authors studied the early stages of WTB host colonization behavior in a walnut germplasm collection of 16 species and hybrids (1 500 trees) in Solano County, California. Landing rates were assessed on unbaited branches of live trees (May–October, 2012–2013) and on aggregation pheromone-baited cut branch sections (September–October 2013). In both cases, clear plastic sheets coated with Stikem Special were used as cylindrical traps. Higher landing rates were recorded on unbaited and baited branches of *J. californica* and *J. hindsii*, two black walnut species native to California. Both *J. regia* (unbaited), used for commercial nut production, and *J. nigra* (baited), a valuable timber species with extreme susceptibility to the disease, elicited lower landing rates than the California species. These results suggest visual, tactile, or chemical cues may allow WTB to distinguish hosts prior to fully penetrating the bark.

Eastern hemlock-dominated forest ecosystems of northeastern Ohio and possible changes with the impending infestation by the hemlock woolly adelgid. Hix, D. (*Ohio State University, USA; hix.6@osu.edu*), Macy, T., Goebel, C., Matthews, S. (*Ohio Department of Natural Resources, USA; thomas.macy@dnr.state.oh.us; goebel.11@osu.edu; matthews.204@osu.edu*).

Eastern hemlock (*Tsuga canadensis* (L.) Carr.) is a foundation tree species of forest ecosystems in the eastern United States. Since its accidental introduction in 1951, hemlock woolly adelgid (*Adelges tsugae* Annand; HWA) has caused widespread mortality of eastern hemlock in an expanding portion of its range; the adelgid is expected to reach northeastern Ohio within decades. To establish pre-infestation characterization of forest composition, the authors sampled the two main types of hemlock forests in that area, collecting vegetation and environmental data from seven mature stands. Principal components analysis showed clear separation between the two physiographic regions based on slope percent and slope position. Although multi-response permutation procedure (MRPP) detected a significant difference in the seedling stratum between physiographic regions, MRPP did not detect differences in the overstory, sapling, or ground-flora. Redundancy analysis revealed species-environment relationships consistent with species life-history traits and habitat requirements. The Forest Vegetation Simulator-HWA Event Monitor was then used as a forecasting tool, suggesting the potential for an 80% reduction in the basal area of eastern hemlock 30 years following HWA infestation in both regions. This research alerts forest managers to the potential loss of this foundation species, resulting in drastic alterations of forest composition, structure, and functional processes.

Nitrogen deposition and critical loads for Sierra Nevada (USA) forests: a comparison of measurement techniques and ecosystem responses. Hunsaker, C., Bytnerowicz, A. (*U.S. Forest Service, USA; chunsaker@fs.fed.us; abytnerowicz@fs.fed.us*), Johnson, D. (*University of Nevada, USA; forestrangesoils@gmail.com*), Fenn, M., Jovan, S. (*U.S. Forest Service, USA; mfenn@fs.fed.us; sjovan@fs.fed.us*).

Forest health is affected by nitrogen deposition and processing, and critical loads have been suggested for ecoregions of the United States. The Kings River Experimental Watersheds, run by the U.S. Forest Service, provides a long-term mountain research site for comparison of chemical sampling techniques and ecosystem responses, including stream water quality, soils, and lichens over a 10-year period. A lichen survey and 5 years of air-concentration sampling with passive filters provide an extensive sampling array. Wet deposition is sampled at one location as part of the National Atmospheric Deposition Program. More intensive sampling occurs within eight experimental watersheds that cover 990 ha; ion-exchange resin samplers provide annual N fluxes to the ground and shallow mineral soils at 460 points. At two locations, a different type of resin sampler provides comparison data for wet and dry season deposition. At 3–5 kg/ha/yr sensitive lichen species are adversely affected in the Sierra Nevada; at 17 kg/ha/yr N leaching is expected. Above-ground resin samplers indicate annual loadings of 5–11 kg/ha. Soil leachate fluxes range from 2–3 kg/ha in 2004 to 6–20 kg/ha in 2008. Both spatial and between-year variations have been large and will be discussed.

First releases of *Selitrichodes neseri*, a new biological control agent for the eucalyptus gall wasp, *Leptocybe invasa*. Hurley, B., Baffoe, K., Slippers, B., Garnas, J., Wingfield, M. (*FABI-University of Pretoria, South Africa University of Pretoria, South Africa; brett.hurley@up.ac.za; kwabena.baffoe@fabi.up.ac.za; Bernard.Slippers@fabi.up.ac.za; jeff.garnas@fabi.up.ac.za; mike.wingfield@fabi.up.ac.za*).

Selitrichodes neseri (Hymenoptera: Eulophidae), a recently described parasitic wasp of an invasive Eucalyptus pest, *Leptocybe invasa* (Hymenoptera: Eulophidae), was recently released in South Africa as a biological control agent. This was the first release of this wasp outside its native range of Australia. To assess establishment success, 10 release sites were monitored across the regions of South Africa where *Eucalyptus* spp. are extensively cultivated. Branches were collected from nine trees per site, radiating from the release tree. Surveys were repeated every 3 months. Collected material was stored in plastic emergence boxes and emergences of *L. invasa* and *S. neseri* monitored for 4 weeks. A year after the first releases, *S. neseri* adults were consistently recaptured from all the release sites. In addition, the sampling data reveal that *S. neseri* is gradually spreading farther outwards from the release trees. Parasitism rates were expectedly low, but have been increasing over time. Surveys are being continued to understand the rate of establishment and the factors that influence establishment.

Global patterns of diversity of the Sirex-Amylostereum-Deladenus symbionts and their implications for control. Hurley, B., Slippers, B., Mlonyeni, X., Fitza, K., Wooding, A. (*FABI-University of Pretoria, South Africa University of Pretoria, South Africa; brett.hurley@up.ac.za; Bernard.Slippers@fabi.up.ac.za; osmond.mlonyeni@fabi.up.ac.za; Katrin.Fitza@fabi.up.ac.za; amy.wooding@fabi.up.ac.za*), Garnas, J., Wingfield, M., Boissin, E., Postma, A.

A number of studies over the past 15 years have attempted to reconstruct the introduction and invasion history of *Sirex noctilio* and *Amylostereum areolatum*, as well as their parasites, which are used in biological control programs. These studies have been hampered by poor collection of the organisms from native areas, as well as by a lack of tools for studying their diversity and relationships. However, there has been considerable improvement in the quality of these collections and the tools for analyzing the associated data. It is now clear that there is a complex history of introduction, and reintroduction, of the woodwasp in many parts of the world, which is in contrast to the limited extent of introductions of parasitoids. There is consequently a broad discrepancy in diversity between the parasites and their hosts, which are important factors in biocontrol programs. The completion of the genome sequences of *S. noctilio*, *A. areolatum*, and the parasitic nematode, *Deladenus siricidicola*, offers unprecedented opportunities to better characterize the patterns and consequences of co-evolution and rapid evolutionary changes in non-native environments. Such insights promise to increase the understanding of the biology of these organisms and will likely offer novel avenues for control.

Genetic diversity of the deodar weevil, *Pissodes nemorensis* (Coleoptera: Curculionidae), in its introduced range in South Africa. Hurley, B. Wondafrash, M., Garnas, J., Slippers, B.(*FABI-University of Pretoria, South Africa; brett.hurley@up.ac.za; mesfin.gossa@fabi.up.ac.za; jeff.garnas@fabi.up.ac.za; Bernard.Slippers@fabi.up.ac.za*).

The deodar weevil (*Pissodes nemorensis*) is native to North America and has been introduced to Russia, Japan, and South Africa. It causes significant damage to pines, cedars, and spruces and has also been associated with various fungal pathogens of pines. In

South Africa *P. nemorensis* was first detected in 1942 on pine trees in the Port Elizabeth area. It has subsequently spread throughout the major pine-growing regions of the country and occurs on all commercially grown pine species, most likely because of the widespread movement of timber throughout the country and the capacity of the weevil to fly long distances. In this study the authors ask whether the current populations of *P. nemorensis* in South Africa are the result of a single or multiple introductions. These scenarios are expected to lead to different patterns of population genetic diversity, and might even have resulted in the introduction of cryptic species. To address these questions, cytochrome oxidase I (CO-I) gene sequence data and microsatellite markers are being used to characterize the genetic diversity of *P. nemorensis* samples collected across the major pine-growing regions in South Africa. The data collected during this study are important to consider when attempting to improve management of this pest.

Advances in the knowledge of *Eucalyptus* gall insects in Uruguay: current status and future prospects. Jorge, C. (*Universidad de la Republica, Uruguay; carolina.jorge@cut.edu.uy*), Gómez, D., Martinez, G. (*Instituto Nacional de Investigación Agropecuaria (INIA), Uruguay; dgomez@tb.inia.org.uy; gmartinez@tb.inia.org.uy*), Reyna, R. (*UPM-Forestal Oriental, Uruguay; rossana.reyna@upm.com*).

Uruguay has 1 million ha forested with exotic species, and 75% of this area is in *Eucalyptus* plantations. A national silvicultural practice characterized by large-scale plantations with monocultural stands makes it mandatory to carry out phytosanitary surveillance to prevent the entrance of new pests. A significant increase in insect invasions on *Eucalyptus* production areas has been observed in recent years. Gall-forming insects cause concern because of the risk they pose to young plantations. *Leptocybe invasa* Fisher & La Salle (Hymenoptera: Eulophidae) is considered one of the most invasive species reported in *Eucalyptus*. It colonized the region in 2008 when it was found in Brazil. It was officially reported in Uruguay in 2013. Although no economic losses have been recorded in Uruguay to date, it is considered a serious problem in Brazil and Argentina. Current studies on gall-forming insects in *Eucalyptus* are scarce in Uruguay. In order to develop management strategies for this species and others in this guild, a national survey has been implemented, and studies on bioecology and species distribution are ongoing.

Siberian pine mortality in the Southern Siberian Mountains. Kharuk, V. (*Sukachev Institute of Forest, Russian Federation; kharuk@ksc.krasn.ru*).

The causes and spatial patterns of Siberian pine mortality were analyzed based on satellite and dendrochronology data. Climate variables studied included temperature, precipitation, and drought index. Stand mortality was first detected in the year 2006 at an elevation of 650 m, and extended up to 900 m by the year 2012. The area of dead stands and the upper mortality line were correlated with increased drought. The uphill margin of mortality was limited by elevational precipitation gradients. Greatest mortality occurred on southern slopes within a 10–30° slope range and on convex terrain. Tree radial increment was correlated with drought index ($r^2 = 0.37$). The results showed the primary role of drought stress on stand mortality. A secondary role was played by bark beetles and root fungi attacks. The observed Siberian pine mortality is part of a broader phenomenon of "dark needle conifer" (DNC: Siberian pine, fir, and spruce) decline in European Russia, Siberia, the Russian Far East, and Belorussia. In addition, birch mortality was documented in the Trans-Baikal area. All locations of stand mortality coincided with areas of observed increases in drought. With increased aridity, DNC within the southern part of its range may be replaced by drought-resistant *Pinus silvestris* and *Larix sibirica*.

Heavy economic damage due to rot pathogen *Heterobasidion annosum s.l.* in close-to-nature managed Norway spruce forests in the Italian Alps. La Porta, N. (*Edmund Mach Foundation (MOUNTFOR), Italy; nicola.laporta@fmach.it*), Battistel, G., Gori, Y. (*Edmund Mach Foundation (FEM-IASMA); gianantonio.battistel@fmach.it; yuri.gori@fmach.it*).

Root and butt rot pathogens are important fungi that affect the forest carbon sequestration by destroying the root and stem wood of forest trees, by predisposing the forest to windfalls, and by limiting tree growth. *Heterobasidion annosum sensu lato* is the main pathogen affecting conifers in the Northern Hemisphere. The incidence of natural infection of *Heterobasidion* spp. and economic damage were recorded in Norway spruce (*Picea abies*) forests in the Central-Eastern Italian Alps. About 1 900 trees were sampled from 63 transects in pure stands of Norway spruce or mixed stands dominated by Norway spruce. Results showed that the pathogen was present in most of the transects, though with different incidence. All three species of *Heterobasidion* were found in the study, but only one or two species were found in any given transect. The percentage of trees infected in each transect differed remarkably, ranging from 39 to 100%. The average percentage of infected stump surface differed between transects, ranging from about 10 to 49%. This study shows the recurrent and heavy presence of *H. annosum* in Alpine forests and the surprisingly heavy damage caused by this fungus. The ecological role of this pathogen and its economic impact are discussed.

***Cephalcia arvensis* defoliation on Norway spruce: a case study analysis by tree-rings and stable isotopes approach.** La Porta, N. (*Edmund Mach Foundation (MOUNTFOR), Italy; nicola.laporta@fmach.it*), Gori, Y., Camin, F (*Edmund Mach Foundation (FEM-IASMA), Italy; yuri.gori@fmach.it; federica.camin@fmach.it*), Carrer, M. (*University of Padova, Italy; marco.carrer@unipd.it*), Battisti, A. (*University of Padova, Italy; andrea.battisti@unipd.it*).

This paper focuses on carbon and oxygen stable isotopes in conjunction with tree-ring chronologies to investigate the short- and long-term effects of *Cephalcia arvensis* defoliation on *Picea abies*. The authors found massive growth loss and significantly different carbon and oxygen stable isotope patterns associated with insect feeding; while carbon isotope values increased, oxygen isotope values decreased in the defoliated trees. Depletion of $\delta^{18}O$ reached its peak of –22.8‰ (1989), coinciding with the year of highest growth loss. The values in defoliated trees were close to those in control trees (1990), 2 years before complete growth recovery (1992). The depletion of $\delta^{18}O$ started 1 year ahead of growth reduction, whereas ^{18}O enrichment started 1 year before growth recovery. The authors hypothesized that a period of severe drought in the outbreak area before the insect attack may have caused the trees to mobilise reserve starch, which made trees more susceptible to *Cephalcia* attack as a result of increased soluble sugars and aminoacids concomitant with the direct effect of high temperature and dry weather on the insect populations. Moreover, the carbon and oxygen isotope patterns could be explained by both an increase in photosynthetic rate and a resort to starch reserves following insect feeding.

Responses of urban forests to environmental stress. Liu, Z., He, X., Chen, W. (*Chinese Academy of Sciences, China; forestry83@gmail.com; forestry63@gmail.com; fangbing_219900@163.com*).

Environmental stress, such as heavy metal contamination and greenhouse gas emissions, is becoming increasingly serious as urbanization intensifies. More attention is being paid to the influence of environmental stress on urban forests, because it poses a great risk to the sustainability of the urban environment and to human health. The present study, which is based on previous studies by this research team, reviews control of contamination sources, chemical speciation, and distribution of environmental stress. The physiological and biochemical responses of different urban forest plants to environmental stress are studied. Different methods and principles of remediation technologies for urban environmental stress are proposed.

Modeling forest insect distributions in Europe under climate change scenarios. Lyytikäinen-Saarenmaa, P., Saarenmaa, H. (*University of Helsinki, Finland; paivi.lyytikainen-saarenmaa@helsinki.fi; hannu.saarenmaa@uef.fi*), Fetyukova, Y. (*University of Eastern Finland, Finland; yuliya.fetyukova@uef.fi*), De Giovanni, R. (*Reference Center on Environmental Information, Brazil; renato@cria.org.br*), Williams, A. (*University of Manchester, UK; alan.r.williams@manchester.ac.uk*), Kulawik, R., Obst, M.

Climate change effects on distributional shifts of forest insects are still unclear. A predictive approach is a key to estimate the effect on forest ecosystems. Ecological niche modeling (ENM) is a technique for analysing distributional changes of organisms, such as spread of invasive species. Less work has been carried out on economically important species, such as forest pest insects. Such analyses require modeling the effect of host tree species, which is still difficult with current ENM tools. The authors present an analysis of distribution shifts of major European forest pest insects under climate change scenarios. This involves modeling their historical and future distribution, and using the predicted host tree distributions as environmental layers. Both Global Biodiversity Information Facility (GBIF) occurrences and forest damage reports from the European Forest Institute (EFI)-Alterra Database of Forest Disturbances in Europe were used. Workflow tools of the BioVeL project (see www.biovel.eu) were used. The predictions showed that damage by most major forest pests will spread about 500 km towards the northeast with extended occupation of suitable habitats by the year 2050. However, much uncertainty lies in how far the host trees will actually be capable of moving or being planted, and in the role of other drivers affecting forest insects.

Impact of nitrogen fertilizer factory pollution on ground vegetation of pine forests in Lithuania. Marozas, V., Augustaitis, A. (*Aleksandras Stulginskis University, Lithuania; vitas.marozas@asu.lt; algirdas.augustaitis@asu.lt*).

The present study aimed at an evaluation of species composition and abundance of understory vegetation of pine-dominated forests affected by nitrogen fertilizer factory pollution (JSC Achema, Lithuania). Ten sampling plots were established at different distances from the factory in the direction of the prevailing wind. Mature stands of Scots pine (>100 yr old) on fresh, low-fertility soils were selected for sampling of vegetation. Assessment of herbaceous plants was done in early July 2011. Ellenberg indicator values were used to evaluate how vegetation differed with distance from the fertilizer plant. Results showed that the total number of species of herbaceous plants decreased from 37 to 28 species as distance from the fertilizer factory increased. In the study plots located closest to the factory (3 and 5 km) the dominant species were *Oxalis acetosella* L., *Rubus idaeus* L., *Impatiens parviflora* DC., and *Chelidonium majus* L. Farther from the factory abundance of nitrophilic species declined; and at 9.2 km from the factory species characteristic to pine forests, such as *Vaccinium myrtillus* L. and *V. vitis-idaea* L. dominated. Moss species such as *Hylocomium splendens* (Hedw.) Schimp. and *Pleurozium schreberi* (Brid.) Mitt. dominated in all study plots. Ellenberg indicator values for nitrogen and pH decreased with increasing distance from the factory.

Seasonal dynamics of the bronze bug (*Thaumastocoris peregrinus*) on *Eucalyptus* spp. plantations after 4 years of monitoring. Martinez, G., Gómez, D. (*Instituto Nacional de Investigación Agropecuaria, Uruguay; gmartinez@tb.inia.org.uy; dgomez@tb.inia.org.uy*), Centurión, C., Reyna, R., (*UPM-Forestal Oriental, Uruguay;rossana.reyna@upm.com*), González, A., Amaral, L. (*Montes del Plata, Uruguay; alejandro.gonzalez@montesdelplata.com.uy; laura.amaral@montesdelplata.com.uy*), Regusci, A.

The bronze bug is a major pest of Eucalyptus tree plantations worldwide. The first outbreak of this species in Uruguay was reported in summer 2008. Soon after that, a monitoring network was installed throughout the country by using yellow rectangular sticky traps (10 cm × 12.5 cm) attached to a tree trunk at 1.80 m and replaced monthly. Five to nine traps were established in more than forty monitoring stations on forestry plantations covering different ages, densities, and Eucalyptus species. Here results are shown for 4 years of monitoring in two permanent monitoring stations. Captures start to increase by the end of October, reaching a peak in late summer (March–April) and then decrease to almost disappear by July–September. This seasonality is consistent with temperature, although peaks differ slightly among Eucalyptus species. *Eucalyptus benthamii* presented earlier and higher captures than the extensively planted species *E. grandis* and *E. dunnii*. Local rainfall during summer also affected abundance of the bronze bug. The authors discuss the implications of these finding for the development of an integrated management strategy for the bronze bug.

***Sirex noctilio* host searching behavior: use of reliable infochemicals emitted by fungal symbiont.** Martinez von Ellrichshausen, A., Fernandez Ajo, A., Corley, J. (National Agricultural Technology Institute (*INTA-CONICET), Argentina; andmarv77@gmail.com; afernandezajo@gmail.com; elmallin@gmail.com*).

The woodwasp *Sirex noctilio* is considered a major pest of pine plantations worldwide. Female wasps establish a symbiosis with the basidiomycete *Amylostereum areolatum*. Arthrospores of the fungus, carried in special sacs, are deposited into living trees at the moment of oviposition. Fungal growth within the wood is fundamental for larval nutrition. Previous studies have established a strong spatial aggregation of *S. noctilio* attack, with females favoring previously attacked trees because multiple fungal insertions help weaken the tree and increase larval survival. Therefore, the authors hypothesize that host-searching females will rely on fungal volatiles (in addition to pine infochemicals) as a reliable indication of host suitability. The volatile emissions of fungal growth were investigated, and electrophysiological and behavioral assays were used to establish the relevance of these volatile compounds in the context of female host searching behavior. The authors suggest that some of the fungal volatiles are used as cues during the host searching process, and their potential use in pest monitoring programs is discussed.

Infestation patterns of *Phoracantha semipunctata* (Coleoptera: Cerambycidae) corresponding with a drought-induced dieback event in native host trees in southwestern Australia. Matusick, G., III., Seaton, S., Hardy, G. (*Murdoch University, Australia; G.Matusick@murdoch.edu.au; g.hardy@murdoch.edu.au*).

An outbreak of the native Eucalyptus longhorned borer (*Phoracantha semipunctata*, Coleoptera: Cerambycidae) coincided with a severe drought-induced dieback event in the Northern Jarrah Forest of southwestern Australia in 2010–2011. Although the behaviour of *P. semipunctata* is well known where it is exotic, little is known about its ecology in its native habitats within Australia. Intensive whole-tree sampling was used to investigate population levels, host preference, and within-tree infestation patterns in *Eucalyptus marginata* and *Corymbia calophylla* trees during the outbreak. The density of oviposition sites was similar between host tree species, whereas infestation levels were significantly greater in marri compared to jarrah, including 20% more larval galleries per oviposition site and 46% more emergence holes/m^2. Larval damage in sapwood was extensive (mean of 48%) in both species. Significant positive correlations were found between density of oviposition sites, larval galleries, and emergence holes with stem diameter. This study is the first to establish the association between drought and outbreak levels of *P. semipunctata* in southwestern Australia, raising questions about the future impact of *P. semipunctata* with continued climate change in this region. It is also first to describe the within-tree distribution of the beetle in susceptible hosts in its native environment in Australia.

Interactive effects of white pine needle damage and climate change on forest health and carbon-water dynamics across the northeastern United States. McIntire, C., Asbjornsen, H., Broders, K. (*University of New Hampshire, USA; cameron.d.mcintire@gmail.com; heidi.asbjornsen@unh.edu; kirk.broders@unh.edu*), Munck, I. (*U.S. Forest Service, USA; imunck@fs.fed.us*), Livingston, W. (*University of Maine, USA; WilliamL@maine.edu*).

White pine needle damage (WPND) is a complex of fungal pathogens currently affecting forests in the northeastern United States. Since 2010, white pine chlorosis and defoliation caused by WPND have been observed in Maine, Massachusetts, New Hampshire, and Vermont. Warmer temperatures and higher-than-average spring precipitation in the region are thought to be exacerbating WPND, and the potential exists for positive feedback driven by interactive effects of the needle cast on water and carbon cycling, yet empirical data are lacking. This research addresses the impacts of these defoliations on forest health. The goals of this study are to (1) monitor the severity and spread of WPND, (2) determine to what extent defoliations are affecting the dynamics of transpiration and soil moisture of infected white pine stands, (3) measure annual changes in growth rates, and (4) develop a climate-based model for predicting disease outbreaks. The effects of WPND are measured through variation in sap flow rates to derive whole tree transpiration rates and dendrochronological analysis between healthy and diseased individuals. Shifts in both transpiration and carbon sequestration of this economically important and widespread species may have significant implications for managing New England forests for both ecological health and hydrologic services.

Climate change-induced shift in voltinism of eastern larch beetle (Dendroctonus simplex) associated with increased tree-killing behavior. McKee, F., Aukema, B. (*University of Minnesota, USA; mcke0620@umn.edu; bhaukema@umn.edu*).

The eastern larch beetle (*Dendroctonus simplex*) occasionally erupts and kills large numbers of mature tamarack (*Larix laricinia*). In Minnesota (USA), sustained epidemic behavior of the beetle has been noted since 2000, which deviates from historic patterns in this southern extent of its range. Biotic factors that predispose trees to attack, such as defoliators, have been noticeably absent. The authors examined trees over a 2-year period in northern Minnesota, and measured colonization and development throughout the growing seasons. Several lines of evidence suggested that additional insect generations were not sister broods as commonly understood from the limited body of literature on this insect, but rather F1 progeny that were attacking new trees in late summer. These progeny were able to successfully complete reproduction, overwinter, and emerge en masse the following spring. Laboratory studies demonstrate that this insect does not have an obligatory reproductive diapause. The authors postulate that bivoltine reproduction is the reason for enhanced outbreak activity in Minnesota in the absence of normal predisposing factors.

Effects of air pollution and climate change on forest growth in the Southern Carpathians (Retezat and Bucegi-Piatra Craiului Mountains). Neagu, S., Badea, O., Silaghi, D. (*Forest Research and Management Institute, Romania; badea63@yahoo.com; dianamicasm@yahoo.com*).

Forest ecosystem condition is mainly influenced by the negative action of air pollution and climate change as well by other stressors (biotic and abiotic). Tree growth and forest dynamics are considered as the primary indicators of stability, function, and productivity of forest ecosystems. Since the year 2000 interdisciplinary research at long-term ecological research sites at Retezat and Bucegi – Piatra Craiului in the Southern Carpathians has collected data provided by successive, permanent, and continuous measurements. Results showed different average annual growth in volume related to specific conditions of vegetation, air pollution, climate, and site by comparing healthy trees (crown defoliation 25%) versus damaged trees (crown defoliation >25%). Healthy trees recorded higher values of mean annual growth in comparison with the damaged trees with differences of 0.5–7.1 m^3/ha/yr (*Picea abies*), 0.8–6.9 m^3/ha/yr (*Fagus sylvatica*), and 0.9–5.4 m^3/ha/yr (*Abies alba*). Mean annual growth in damaged trees was up to 40–45% less than that recorded by healthy trees. Knowing the annual volume growth losses due to cumulative effects of air pollution and climate change along with other biotic and abiotic factors allows managers to better predict forest health impacts and to develop mitigation efforts.

Effects of tree species biodiversity on foliar fungal pathogen regulation: understanding the spread of the ash dieback pathogen, *Hymenoscyphus pseudoalbidus*. Nguyen, D., Cleary M., Stenlid, J. (*Swedish University of Agricultural Sciences, Sweden; diem.nguyen@slu.se; Michelle.Cleary@slu.se; jan.stenlid@slu.se*).

The fungal pathogen *Hymenoscyphus pseudoalbidus* has been causing widespread decline of European ash (*Fraxinus excelsior*) across Europe. Recent studies that showed lower genetic variability in European *H. pseudoalbidus* populations compared with that found in a Japanese population of the fungus suggest that the pathogen in Europe likely originated from East Asia. Population

genetic investigations have been performed to determine the population structure of *H. pseudoalbidus* across Europe and the fungus was found to be without any genetic population structure. These studies focused on fungal isolates throughout Europe, but no work has been done to determine the finer-scale resolution within one locality across a tree species diversity gradient. In this study, the authors aim to address whether mixtures of ash with various broadleaved tree species can help regulate the impact of the pathogen by limiting the spread of fungal spores. In a 12 km × 5 km area in the Hainich National Park in Germany, ten 30-m^2 plots were chosen that consisted of ash in various mixtures with broadleaved tree species. Sclerotized ash petioles were collected from selected target trees and microsatellite analyses were performed directly from subsections of these petioles. The authors tested the hypothesis that less genetic variation would be found among fungal populations in mixtures than in pure stands of ash.

Life cycle, survivorship, and control of an insect pest, *Trachys yanoi* (Buprestidae, Coleoptera). Ohsawa, M. (*Yamanashi Forest Research Institute, Japan; oosawa-ujk@pref.yamanashi.lg.jp*).

Trachys yanoi is a well-known and widespread insect pest of *Zelkova serrata*. The life cycle and survivorship of this insect were studied by field observation and breeding in laboratory in order to find methods of controlling the damage caused by this insect. Adults came out of hibernation and started feeding on Zelkova leaves from the outside of the leaves in April. After mating, they laid eggs on the Zelkova leaves. Eggs hatched and larvae as leaf miners started eating the interior of the leaves. Zelkova trees shed their leaves (early leaf abscission) together with the larvae. The larvae became pupae inside of fallen leaves and emerged as adult beetles from mid-July to early August. The adults of the new generation fed on Zelkova leaves in the crown. In October, they hibernated under the tree bark. Survival rate of this insect was relatively low in the egg stage. Parasitic wasps killed the insect in the larval stage, and *Beauveria bassiana* (insect disease) killed the adult beetles during hibernation. The removal of fallen leaves together with larvae or pupae of this insect in late July was found to be the most effective control method tested.

Nursery pest management of *Phytolyma lata* Walker (Scott) attack on Iroko (*Milicia excelsa* Welw C. C. Berg) seedlings. Olajuyigbe, S. (*University of Ibadan, Nigeria; lekito2001@yahoo.com*).

The establishment of plantations of *Milicia excelsa* has been constrained by the gall-forming *Phytolyma lata*, which causes extensive damage to young plants. This study aimed to prevent *Phytolyma* attack on *Milicia* seedlings in the nursery using chemical control and a physical barrier (screen house). Ninety 6-month-old seedlings of uniform growth were selected from a population of seedlings obtained from the same seed source. Thirty seedlings were placed in a screen house (SHS), and 30 seedlings (TRT) were placed in the open nursery and treated fortnightly with a low concentration (0.05%) water-based insecticide (Lambda-Cyhalothrin). Thirty untreated seedlings (UNT) were also placed in the open nursery as a control. The survival rate, height, and collar diameter were measured fortnightly for 24 weeks. After 10 weeks, only the untreated seedlings were attacked by *Phytolyma* insects, but no mortality was recorded during the study. There was no significant difference in the collar diameter growth of seedlings in all treatments. However, there were significant differences in the total height with an increase of 22% and 58%, in TRT and SHS, respectively, whereas UNT seedlings had a height growth of –0.27%. The provision of a physical barrier proved to be the most effective management strategy to prevent *Phytolyma* infestation, and chemical control was a successful alternative.

Biogenic VOC emission from silver birch under ozone and nitrogen stress. Paoletti, E., Carriero, G. (*National Research Council, Italy; e.paoletti@ipp.cnr.it; carriero@ipp.cnr.it*), Mills, G., Hayes, F., Brunetti, C. (*Centre for Ecology and Hydrology, UK; gmi@ceh.ac.uk; fhay@ceh.ac.uk; c.brunetti@ipp.cnr.it*), Tattini, M.

Silver birch grows in cold climates and farther north than any other tree species. It is a monoterpene and sesquiterpene emitter (Vuorinen *et al.*, 2005). This emission of volatiles from plant leaves may be altered under environmental stress (Beuchamp *et al*., 2005; Loreto and Schnitzler, 2010;), and contribute to the formation of aerosols and ozone (Fehsenfeld *et al.*, 1992). The main objective was to explore whether *Betula pendula* changes quality and quantity of volatile organic compound (VOC) emissions when exposed to two typical climate change stressors, i.e., elevated ozone and nitrogen availability. Trees were exposed to two levels of ozone in the air and three levels of nitrogen in the soil in solardomes. The emission of monoterpenes decreased as much as 45% by increasing nitrogen fertilization from 10 to 70 kg/ha/yr under low levels of ozone in the air. In contrast, nitrogenreduced the emission of monoterpenes by just 8% in plants exposed to high ozone levels. The effects were compound-specific, with the most abundant α-pinene and limonene showing the most significant variations. These results are discussed in the light of future scenarios involving global climate models and atmospheric VOC budgets.

Ozone-induced differences in phenology and antioxidants of poplar trees treated and untreated with ethylenediurea (EDU). Paoletti, E., Pignattelli, S., Carriero, G., Bartolini, P., Vettori, C. (*National Research Council, Italy; e.paoletti@ipp.cnr.it; sara.pignattelli@gmail.com; carriero@ipp.cnr.it; cristina.vettori@igv.cnr.it*), Paffetti, D.

Ozone (O_3) is an important phytotoxic air pollutant and a significant greenhouse gas (Bytnerowicz *et al.,* 2007). Chronic O_3 injury mimics other environmental stressors, such as pathogen attacks. Ozone may weaken freezing tolerance (FT) and predispose trees to frost injury (Ranford and Reiling, 2007). Plant FT develops in autumn as a response to shortening of photoperiod and low temperatures; therefore, autumnal warming may affect the developing of FT in plants. Both O_3 and freezing stress can increase the production of reactive oxygen species (ROS) such as O_2^- and H_2O_2, and antioxidants such as glutathione (GSH) and ascorbate (AsA) (McKersie *et al*., 1997; Castagna and Ranieri, 2009). To prevent ozone injury, ethylenediurea (EDU) has been widely used (Manning *et al*., 2011). The objective of this study was to understand whether ambient ozone exposure is affecting the ability of plants to overwinter, by investigating acclimation/de-acclimation to cold stress and freezing tolerance in an O_3-sensitive poplar clone (Oxford clone) treated and untreated with EDU as soil drench. This study presents the result of phenology, foliar content, and gene expression of ROS and antioxidants. Preliminary results show that spring flushing is delayed and shoot lengthening is decreased in untreated poplars.

Ozone fluxes and epidemiology of ozone injury to forests. Paoletti, E. (*National Research Council, Italy; e.paoletti@ipp.cnr.it*), Sicard, P. (*ACRI-ST, France; pierre.sicard@acri-st.fr*), De Marco, A. (*National Agency for New Technologies (ENEA), Italy; alessandra.demarco@enea.it*).

Although tropospheric ozone is an important greenhouse gas and phytotoxic air pollutant (Bytnerowicz *et al*., 2007), quantification of its effects on real-world forests is challenging. Ozone, in fact, is a strong oxidant and does not accumulate in the environment. Effects on forest indicators are thus not specific. In addition, effects depend on the amount of ozone entering through the stomata (flux) rather than the amount of ozone in the air (exposure) (Paoletti and Manning, 2007). Epidemiology is the study of patterns, causes, and effects of diseases. Large-scale epidemiological investigations focused on ozone impacts on plant indicators may provide a quantitative assessment of ozone injury. A complication is that ozone co-varies with beneficial (air temperature, solar irradiation) and detrimental (soil water stress) factors. Most of the previous epidemiological evaluations of the environmental impacts of ozone focus on ozone exposure only. Here novel results are reported from cross-comparing soil, meteorological, ozone, and plant databases for Italian and French forests, where stomatal ozone fluxes were investigated. The results were obtained within the FO3REST Life+ ENV/FR/208 project.

Flight activity, life history, and host selection behavior of the walnut twig beetle in its native range in the southwestern United States. Parker, C., Flint, M., Nadler, S. (*University of California, USA; corwin.parker@gmail.com; mlflint@ucdavis.edu; sanadler@ucdavis.edu*), Graves, A., Seybold, S. (*U.S. Forest Service, USA; adgraves@fs.fed.us; sjseybold59@gmail.com*).

The walnut twig beetle (*Pityophthorus juglandis* (Coleoptera: Scolytidae); WTB) is native to the southwestern United States, where historically it has fed with little impact on the phloem of the branches and main stem of Arizona walnut, *Juglans major*. However, in recent decades, the beetle has substantially increased its range, carrying with it a fungus, *Geosmithia morbida*, which infects the phloem of many species of walnut. In 2013, the authors conducted comparative studies of the biology of WTB in California and New Mexico. Aggregation pheromone-baited *J. major* branches and flight traps were used to document WTB flight patterns and life history. Host selection behavior was assessed with pheromone-baited branch sections of *J. major*, *J. microcarpa*, *J. hindsii*, *J. nigra*, and *J. regia*. In these experiments, the branch sections were suspended on poles for 2–3 weeks in infested locations in both states. The attack densities varied by species with *J. hindsii* and *J. nigra* the most heavily attacked in both states; *J. microcarpa* was attacked at the lowest density. Rearing studies in the lab to assess productivity in the various hosts showed that branch sections of *J. hindsii* yielded far more brood than branch sections of *J. major* and *J. microcarpa*.

Optimal control strategies of forest pathogens in a heterogeneous landscape: a French case study. Petucco, C. (*National Institute for Agricultural Research (INRA), France; claudio.petucco@nancy.inra.fr*).

Forest pests are the most evident signs of an "unhealthy" forest. Certain management practices such as the extensive use of monoculture plantations favor emergence of pests. Moreover, global climate change can lead to decline of forest ecosystems and their capacity to satisfy human needs. Yet monocultures continue to be implemented and are considered to be the most profitable option. This work aims to evaluate the optimal pest control strategy in a heterogeneous landscape under different climate scenarios. First analysis is focused on a heterogeneous landscape divided into grid cells characterized by monoculture plantations for which the number of trees, standing volumes, and number of infected trees are known. The pest spatial and temporal dynamics depend on climate conditions (winter minimum temperature and sunshine duration) and on the density of host trees. Optimal control techniques were used to determine the intensity of monitoring and control in order to minimize total damage and pest control costs within a rotation period. Second, the analysis explores the profitability of having a mixed forest by replacing the dominant species with a second one not affected by the pathogen. The model is applied to the pine processionary moth (*Thaumetopoea pityocampa*) infection in the Landes region, France.

The good and the bad: tradeoffs between disease resistance and symbionts in loblolly pine. Piculell, B., Hoeksema, J. (*University of Mississippi, USA; bjpicule@go.olemiss.edu; hoeksema@olemss.edu*), Eckhardt, L. (*Auburn University, USA; eckhalg@auburn.edu*).

Pine decline and fusiform rust disease are major antagonists in the southeastern United States, negatively affecting crops and causing substantial economic and ecological damage yearly. Interest in addressing the detrimental effects of these pathogenic fungi has inspired extensive investigations into patterns of resistance in dominant pine species, such as loblolly pine (*Pinus taeda*). Little work, however, has focused on the role of pervasive below-ground symbionts of these pines, mycorrhizal fungi. A growth chamber experiment was conducted to investigate genetic variation and trait correlations within loblolly pine as it interacts with both pathogenic and ectomycorrhizal fungi. The experiment uses families of loblolly pine previously determined to be either resistant or susceptible to pathogenic fungi that cause either pine decline or fusiform rust disease. Variation was found among loblolly families in compatibility with different mycorrhizal species. Correlations found between susceptibility to pathogenic fungi and compatibility with symbiotic mycorrhizal fungi, indicate tradeoffs between fungal symbionts and fungal pathogen resistance.

Insect problems: a challenge for reforestation in the Colombian Orinoquia region. Pinzón Florian, O. (*Universidad Distrital Francisco José de Caldas, Colombia; opatriciap@udistrital.edu.co*).

Commercial plantations are increasing in the Colombian Orinoquia region mostly because of the availability of extensive areas previously dedicated to livestock. Most of this area is planted with introduced fast-growing species like *Pinus caribaea*, *Eucalyptus* spp., and *Acacia mangium.* Although forest commercial plantation activity in the region continues to expand, there is concern because of the occurrence of about 30 species of harmful insects. Currently, the main economic damage is caused by leaf-cutting ants (*Atta* spp., *Acromyrmex* sp.) and by beetles (Chrysomelidae : Eumolpinae) in eucalyptus and acacia. Infestations of the sap-sucking insect *Glycaspis brimblecombei* Moore (Hemiptera: Psyllidae) have also been recorded in eucalyptus in the region. A greater number of harmful insects have been found in *A. mangium;* despite extensive plantations, the trees do not reach 10 years of age. The main damage observed in this species is caused by termites in nursery seedlings and young plantations, and holes in the bark and sapwood caused by platypodids with undesirable consequences for wood quality and predisposition to secondary attack by diseases. Reforestation in the Colombian Orinoquia faces challenges regarding health issues before it can be considered as a real economic alternative for local communities.

Climate change and silvicultural practices promoted the emergence of a novel pest of poplar stands. Pointeau, S., Robinet, C., Bankhead-Dronnet, S., Sallé, A., Lieutier, F. (*University of Orléans, France; sophie.pointeau@avignon.inra.fr; christelle.robinet@orleans.inra.fr; stephanie.bankhead@univ-orleans.fr; aurelien.salle@univ-orleans.fr; francois.lieutier@univ-orleans.fr*).

Climate change in recent decades has been directly or indirectly involved in changing the life-history and population levels of many endemic forest insect species, leading to unexpected and unprecedented outbreaks. In spite of difficulties in assessing the complex impact of climate on insect communities, evaluating the effect of climate warming on insect population dynamics remains fundamental to understanding and predicting global warming-induced insect outbreaks in forest ecosystems. To test the hypothesis that climate warming affects the emergence and spread of endemic insects, the authors assessed whether recent climate warming could explain the outbreaks of the woolly poplar aphid (*Phloeomyzus passerinii*), an emerging pest in French poplar stands since 1996. A model of population dynamics was developed to simulate the annual growth potential of *P. passerinii* populations under optimal conditions using a theoretical index based on temperature-dependent biological traits. When host tree data were taken into account, this model successfully indicated the history and current outbreak range of the insect, confirming the effect of climate warming on this emerging aphid pest.

Conserving plant diversity of Central European oligotrophic forest habitats requires goal-oriented management of nutrient cycles. Pyttel, P. (*Albert-Ludwigs-University Freiburg, Germany; patrick.pyttel@waldbau.uni-freiburg.de*), Ewald, J. (*University of Applied Science Weihenstephan-Triesdorf, Germany; joerg.ewald@hwst.de*).

Nitrogen eutrophication poses a major threat to biodiversity. In Central Europe's cultural landscape eutrophication is due to the additive effects of ecosystem recovery from preindustrial land use and of modern deposition from combustion and agriculture. Looking at the intersection of Red List and Ellenberg indicator values for nutrients for forest species reveals that 69% of Germany's threatened vascular forest plants depend on oligotrophic habitats. While forests present a reserve of oligotrophic habitats, their filtering capacity makes them particularly prone to N deposition. A review of management options to counteract eutrophication shows that, under current environmental conditions, the maintenance of oligotrophic forest habitats requires selective removal of nutrients through intensive harvesting of crown biomass or removal of soil organic matter. The arising conflict with other ecosystem functions calls for a careful, site-specific prioritization of goals and optimization of measures.

Invasiveness of *Uromycladium tepperianum* on *Falcataria moluccana* affected by pyroclastic cloud from Merapi Volcano, Yogyakarta, Indonesia. Rahayu, S. (*University of Gadjah Mada, Indonesia; tatarahayu@yahoo.com*).

The objectives of the research were to evaluate changes in the morphological characteristics, survival, and pathogenicity of *Uromycladium tepperianum* in sengon (*Falcataria moluccana*) trees affected by the volcanic cloud from the eruption of Mount Merapi, Indonesia. Inoculum samples were taken from trees that showed gall symptoms. Trees were located on the southern slope of Mount Merapi in the danger, alert, and warning areas, at distances of 3–7 km, >7–11 km, and >11–15 km, respectively, from the top of the volcano**.** Samples were taken at random distances within the sites: fire (directly affected by the pyroclastic cloud), border (indirectly affected), and green (completely uninfluenced). Based on the artificial inoculation test, pathogenicity of each sample including germination, penetration, and infection ability was observed. Severity of gall rust disease in *F. moluccana* planted around the mountain was also evaluated. Results showed that the spores of *U. tepperianum* from the border location, had higher pathogenicity and aggressiveness, indicated by a higher percentage of germination, faster penetration, and higher infection rate, as well as a greater ability to produce galls, compared to spores from the fire and green locations. The rust fungus also became very invasive and caused an epidemic in the recently planted *F. moluccana*.

Insect frugivores and their impact on the regeneration of mangrove species in the West Coast of India. Remadevi, O.K., Latheef, A., Chatterjee, D. (*Institute of Wood Science and Technology; okremadevi@gmail.com; lathifc@gmail.com; yuv.jyoti@gmail.com*).

The conservation and management of mangrove forests deserve great attention because of the well-known importance and utility of mangroves. Insect frugivores feeding on fruits, seeds, and also propagules, were found to have a sizable effect on regeneration of mangrove species. A study was undertaken to assess insect infestation of fruits, the intensity and nature of damage of the seeds and propagules, and the impact on regeneration of the mangrove species, *Rhizophora mucronata*, *Avicennia officinalis*, *Kandelia* sp., *Bruguiera gymnorrhiza*, and *Sonneratia* sp. in the West Coast of India. Considerable damage was found in the fruits of *Avicennia* (in 70% of samples), where three different types of larvae were found to inflict considerable damage to the fruit. Most of the damage was caused by two species of insects, *Calandra* sp. and *Callistomyia klugii*. A large percentage of the *Sonneratia* fruits (71%) were found to be infested by a noctuid moth and a curculionid beetle. *Coccotrypes* sp. was found attacking nursery-planted seedlings of *Bruguiera gymnorrhiza*. Sixty-four percent of all severely affected seedlings were not viable within 2 months. The impact of insect attack on the initial establishment and survival of mangrove plants is discussed in the paper.

A common foliar endophyte, *Hormonema* sp., suppresses seedling emergence of host species, *Pinus ponderosa*. Ridout, M., Newcombe, G. (*University of Idaho, USA; mridout@uidaho.edu; georgen@uidaho.edu*).

Numerous endophytic fungi inhabit needles of the genus *Pinus*. Both within their host and the greater environment, however, the biological and ecological functions of the greater portion of these organisms are largely unknown. Among the more common endophytes isolated from asymptomatic needles of *Pinus ponderosa* are *Hormonema* spp. In greenhouse germination trials, *H. dematioides* reduced emergence of ponderosa pine seedlings by as much as 66%. Seed from western U.S. provenances of two *Pinus. ponderosa* subspecies, var. *ponderosa* and var. *scopulorum*, subjected to identical conditions had significant reductions in seedling emergence, by 14 and 30%, respectively. The same *Hormonema* isolate, however, failed to reduce emergence of a co-occurring western U.S. conifer *Pseudotsuga menziesii* var. *glauca*. Seedling germination and emergence are critical points for survival and establishment of pines in naturally regenerating stands. Physical and chemical conditions in litter layers have long been implicated as factors in low recruitment of seedlings beneath parent species. The presence of endophytic fungi in senesced foliage presents another potential factor in poor conspecific seedling recruitment in naturally regenerating stands and supports the Janzen-Connell hypothesis of biological diversity in forest systems.

Evaluating North American endophytic fungi for biological control of a coadapted pathogen *Dothistroma* needle blight in *Pinus* sp. Ridout, M., Newcombe, G. (*University of Idaho, USA; mridout@uidaho.edu; georgen@uidaho.edu*).

Red-banded needle blight of pines caused by the North American pathogens *Dothistroma* spp. has been devastating to radiata pine plantations in the Southern Hemisphere. However, the same pathogens are relatively benign in their North American ranges, where they infect a number of North American pines. This divergent response might indicate that some biotic or abiotic factor within the environment checks severity of infection across the native range of both the pines and their pathogens. In classical applications of biological control methods, the best source of biocontrol agents might be found within the natural range of the pathogen. Co-occurring communities of endophytic fungi found in pines within the native range of the pathogen provide a reservoir of potential biocontrol organisms. Seven single-endophyte treatments were applied to emerging needles of 7-year-old trees of *Pinus ponderosa* infected with red-banded needle blight. *Penicillium goetzii* isolated as an endophyte from root tissues of *Pinus ponderosa* reduced lesion extent by 7% on inoculated needles compared to untreated needles on *Dothistroma*-infected needles of *P. ponderosa*. Results from this study indicate that co-occurring endophytes present a potentially valuable tool for classical biocontrol of *Dothistroma* needle blight in intensive exotic pine plantations in the Southern Hemisphere and beyond.

Natural enemy recruitment to the Asian chestnut gall wasp, *Dryocosmus kuriphilus*, a highly invasive pest of chestnut, *Castanea* spp., worldwide. Rieske-Kinney, L. (*University of Kentucky, USA; lrieske@uky.edu*).

The globally invasive Asian chestnut gall wasp, *Dryocosmus kuriphilus*, continues to expand its range, affecting *Castanea* resources throughout invaded areas. Natural enemy recruitment to this globally invasive pest is being evaluated in the context of evolving trophic interactions (parasite – gall wasp and parasite – parasite), and applied biological control. In North America numerous adult parasitoids reared from galls collected throughout infested areas have been identified, but the presence of adult parasitoids is not necessarily indicative of parasitization. In order to determine which species are affecting gall wasp populations, identification of larval parasitoids dissected directly out of developing galls is necessary. But morphological identification of larval parasitoids is difficult. In this research a molecular approach is being used to definitively determine which parasitoids are affecting gall wasp populations. The ITS2 region of parasitoid larvae dissected from developing galls is being compared to adult insects identified morphologically. In this way specific parasitization activity and rates can be directly attributed to specific parasitoid species, opening the door for additional manipulations for biological control.

Colonization dynamics of mountain pine beetle in eastern and western pines: implications to range expansion. Rosenberger, D. (*University of Minnesota, USA; rose0675@umn.edu*), Venette, R. (*U.S. Forest Service, USA; rvenette@fs.fed.us*), Aukema, B. (*University of Minnesota, USA; bhaukema@umn.edu*).

The mountain pine beetle (*Dendroctonus ponderosae* Hopkins) is a disturbance agent native to western North America that intermittently undergoes large-scale outbreaks in *Pinus contorta* and *P. ponderosae*. This insect threatens eastern forests due to recent eastward spread from *P. contorta* forests of British Columbia into the *P. banksiana* forests of northwestern Alberta, and through transport of green pine logs from western states with populations of mountain pine beetle. Here the authors explore the colonization dynamics of this insect in naïve eastern hosts. Logs from two species of native hosts (*P. ponderosae* and *P. contorta*) and four naïve eastern pine species (*P. strobus, P. resinosa, P. banksiana,* and *P. sylvestris*) were harvested and transported to the Black Hills of South Dakota (USA), an area with epidemic populations of mountain pine beetle. There the authors investigated attraction of conspecifics in the field by tunneling beetles and host acceptance. Results indicate that eastern pine species may be susceptible to mountain pine beetle colonization. Differences in attraction among eastern pines and in host entry among regions may cause us to rethink our understanding of colonization dynamics from what is currently known in western forests. Implications to ongoing eastern range expansion of this eruptive herbivore are discussed.

Googling forest pests -Use of Google as a monitoring tool for delimiting the distributional range of forest pests. Rousselet, J., Robinet, C., Rossi, J. (*National Institute for Agricultural Research (INRA), France; jerome.rousselet@orleans.inra.fr; christelle.robinet@orleans.inra.fr; rossi@supagro.inra.fr*).

During the last decade, geospatial data have become increasingly accessible with the advent of new mapping technologies such as Google Earth™, Google Street View™, or Google Trends™. These technologies offer satellite imagery and aerial photos of most of Earth's land surface as well as real-time data documenting different types of outbreaks. The authors investigated how Google Street View could help in assessing the geographical distribution of species and how Google Trends could provide insight for real-time surveillance of pests. The authors worked with the pine processionary moth, the most important pine defoliator in southern Europe. They conclude that Googling forest pests is a promising tool although the approach is still in its infancy; more investigations are required to properly define its range of application and its limitations.

Trees outside forest strongly affect habitat connectivity for forest insects. Rousselet, J., Rossi, J. (*National Institute for Agricultural Research (INRA) France; jerome.rousselet@orleans.inra.fr; rossi@supagro.inra.fr*).

Some forest tree species are commonly used for ornamental purposes and therefore occur frequently in non-forest ecosystems. This paper presents the results of a modeling survey focused on the spatial distribution of trees outside forest (TOF) at the landscape scale. The authors deal with the tree species that host the pine processionary moth (PPM), a major pest for pine species in Europe. They modeled the spatial distribution of TOF by means of an inhomogeneous Poisson process and performed simulations across various landscapes. Results show the TOF constitute a major component of landscape connectivity with regards to PPM dispersal. In particular, large-scale ornamental tree distribution allows pest dispersal across non-forest habitat such as open-field agricultural landscapes.

Population structure and local adaptation of the pine cone weevil *Pissodes validirostris* (Coleoptera, Curculionidae): disentangling the role of the host plant from geography. Roux, G., Bertheau, C., Roques, A. (*National Institute for Agricultural Research (INRA), France; geraldine.roux@orleans.inra.frcoralie.bertheau@gmail.com; alain.roques@orleans.inra.fr*).

This study is focused on the palearctic species *Pissodes validirostris* Gyll. (Coleoptera, Curculionidae), the only known stenoconobionte *Pissodes* species. Whereas all but one species of *Pissodes* feed on the cambium and phloem of Pinaceae, the larval development of *Pissodes validirostris* occurs fully and only in cones and seeds of different pine species and the whole life cycle occurs in the same host species. Here the authors assess evidence for geographical host specialization within this weevil. Use of mitochondrial, nuclear DNA and morphometrical measures revealed that *Pissodes validirostris* probably incorporates five independent evolutionary lineages. No haplotype was shared between the lineages, which suggests the absence of gene flow between these groups. Allopatric fragmentation and colonization routes from distinct refugia during the post-glacial period of both the insect and its associated host pines may explain the present structuring of *P. validirostris* populations. However, given the geographic distribution of the pine species, it is difficult to unequivocally state whether geography or the host species is the main structuring factor.

Anatomy of gall rust in coppice sengon (*Paraserianthes falcataria*) infected by *Uromycladium tepperianum*. Rukhama, S., Fahrudin, F., Rahayu, S., Dwi Nugroho, W. (*Gadjah Mada University, Indonesia; aku.shofi@yahoo.com; fahrudinnanang941@gmail.com; tatarahayu@yahoo.com; wdnugroho@ugm.ac.id*).

Sengon (*Paraserianthes falcataria* (L.) Nielsen) is a fast growing species with short rotation period. However, it is susceptible to attack by the gall rust *Uromycladium tepperianum*. This disease inhibits growth, produces stem defects and even leads to the death of infected trees. This research aims to investigate the anatomy of gall rust in sengon and its wood anatomical changes. A completely randomized study design was used to evaluate two main factors were the condition of gall rust and wood. Gall rust condition included three diameter classes: large (> 1.1 cm), medium (0.8–1 cm) and small (< 0.8 cm), while wood condition was characterized as attacked wood or infected wood. The results showed that in gall rust anatomy, dark substrate contents and vessel elements increase with the size of gall rust. Furthermore, there was smaller diameter of fiber on the gall rust because of lack of giberelin, sclereids skin tumors as well as the wavy pattern on the composition of the callus. Results showed a decrease in the percentage and size of vessel diameter on infected wood as the effects of ethylene hormone. The increase of longitudinal parenchyma and ray cells as result of auxin and cytokinin, and a modification distribution parenchyma into band shape.

Reassessing critical load calculations by ecosystem feedback. Sanders, T., Fischer, U., Seidling, W., Lorenz, M. (*Thünen Institute of Forest Ecosystems, Germany; tanja.sanders@ti.bund.de; uwe.fischer@ti.bund.de; walter.seidling@ti.bund.de; martin.lorenz@ti.bund.de*).

Calculations of critical loads (CL) have been developed since the 1980s under the UNECE Convention on Long-range Transboundary Air Pollution (LRTAP). However, outcomes vary widely depending on the approach. Weathering rates and the gibbsite equilibrium greatly influence the allowable??endurable rates for sulphur and nitrogen deposition obtained, likely due to individual buffering capacities in the soils. The authors use different approaches to calculate CL for acidity and eutrophying nitrogen and compare them with the development of base cation leaching, the base cations–aluminium ratio, and acid neutralising capacity. Furthermore change in pH as well as potential changes in foliar magnesium, calcium, and potassium content are looked at to detect effects on or even shifts within ecosystem functioning. Data derived from the ICP Forests database provide a time-series on deposition, soil and foliar chemistry, growth, and tree condition. Initial results confirm significant variation in CL values due to methodological issues. Calculated CL exceedances are not necessarily manifested in a growth decline; on other sites a decline in tree health is observed even though no exceedances have occurred. The aim of this ongoing work is to modify CL calculations depending on forest ecosystem responses.

Climate alters interactions among bark beetles and symbionts, potentially altering geographic range. Six, D. (*University of Montana, USA; diana.six@cfc.umt.edu*), Addison, A., Powell, J. (*Utah State University, USA; audrey.smith@aggiemail.usu.edu; jpowell@usu.edu*), Bentz, B. (*U.S. Forest Service, USA; bbentz@fs.fed.us*).

Several bark beetles in the genus *Dendoctonus* are involved in obligate symbioses with fungi. The fungi, as well as the host beetles, are highly responsive to temperature, which determines their upper and lower bounds for growth and survival and their overall performance in a given habitat. These symbioses typically involve three partners: a beetle and two fungi. Each fungus provides nutritional benefits to the beetle; however, one fungus is typically superior to the other in supporting beetle fitness. The relative prevalence of the two fungi with a beetle, and subsequently, their effects on beetle population dynamics, is temperature dependent. The fungi possess different temperature tolerances, which leads one to dominate at cooler temperatures and the other at warmer temperatures. Thus, temperature influences beetle fitness, not only through direct effects on development, reproduction, and survival, but also indirectly, through its effects on fungal partners. The authors describe how temperature acts a stabilizing force for these three-way interactions as well as how climate change may act to disrupt stability and decouple one or both partners from the beetle host. The authors also discuss the need to incorporate the fungi into models predicting range expansions and contractions of bark beetle species to increase their accuracy.

Diversity of the parasitic nematode *Deladenus siricidicola* and its relevance as a biological control agent. Slippers, B., Fitza, K., Mlonyeni, X., Hurley, B., Wingfield, M. (*FABI-University of Pretoria, South Africa; Bernard.Slippers@fabi.up.ac.za; Katrin.Fitza@fabi.up.ac.za; osmond.mlonyeni@fabi.up.ac.za; brett.hurley@fabi.up.ac.za; mike.wingfield@fabi.up.ac.za*), Yek, S., Ayres, M., Lombardero, M., Dodds, K., Ahumada, R., Sopow, S.

Deladenus siricidicola is the primary biological control agent for the invasive woodwasp and pest of *Pinus*, *Sirex noctilio*. Although the genetic diversity of invasive populations of *S. noctilio* is relatively high, that of the nematode used in biocontrol programs is extremely limited. Little is known about the diversity of *D. siricidicola* in native populations. In order to investigate the diversity of *D. siricidicola* populations, mitochondrial and microsatellite markers from the whole genome were used. Populations of nematode were from Argentina, Australia, Canada, Chile, New Zealand, South Africa, and the United States, representing putative native and non-native areas. Preliminary results showed extreme homozygosity in the populations from the Southern Hemisphere compared to the Northern Hemisphere strains. The release of a highly efficient single strain of nematode throughout

the Southern Hemisphere has strongly influenced this pattern. To address the low genetic diversity available for biocontrol programs, the above-mentioned strains, and their hybrids, are being screened in culture for potential virulence. Furthermore, a selection of strains is being tested for effectiveness to parasitize the wasp after inoculation into logs. The results are expected to clarify the potential of diversity in a biocontrol agent to improve its use in biological control programs.

Global homogenization of forest insect pests—a case study of *Leptocybe invasa.* Slippers, B., Hurley, B., Wingfield, M., Dittrich-Schröder, G. (*FABI-University of Pretoria, South Africa; Bernard.Slippers@fabi.up.ac.za; brett.hurley@fabi.up.ac.za; mike.wingfield@fabi.up.ac.za; Gudrun.Dittrich@fabi.up.ac.za*).

Global travel and trade has resulted in an increased number of introduced insect pests worldwide, especially in plantation forestry where non-native tree species are planted. The "homogenization" of pests in these plantations around the world has consequently occurred. One of the most serious recent examples of such a pest is *Leptocybe invasa*, which is native to Australia. Since its discovery outside its native range and subsequent description in 2004, it has spread to all continents where *Eucalyptus* is planted. In order to trace the route and extent of *L. invasa* introduction around the world, the authors characterised the genetic diversity within and between populations of *L. invasa* from the origin and introduced environments. The cytochrome oxidase I (CO-I) region of the mitochondrial DNA, as well as simple sequence repeats, were used to determine the genetic diversity of the *L. invasa* populations. Preliminary results suggest that there is little genetic differentiation within the species regardless of geographic origin. Furthermore, distinct populations, or even cryptic species, have been independently introduced, and populations in some regions contain both these types. These data and the historical record of the *L. invasa* global invasion reflect the potential for plant-associated pests to move rapidly and repeatedly around the world.

Digestion in the spruce bark beetle (*Ips typographus* L.): cellulases present! Stefkova, K. (*University of South Bohemia, Czech Republic; kristef@seznam.cz*), Dolezal, P. Okrouhlik, J. (*Academy of Sciences of the Czech Republic & University of South Bohemia, Czech Republic; dolezal@entu.cas.cz; okrouhl@entu.cas.cz*), Miklas, B. (*University of South Bohemia, Czech Republic; b.miklas@centrum.cz*).

The spectrum of digestive enzymes, including glycosidases and proteinases, was investigated throughout the year in the foregut, midgut, and hindgut of the spruce bark beetle (*Ips typographus* L.). The study was primarily focused on the activity of digestive enzymes and determination of their pH optima. Gut fluids of fully feeding adults were positive on cellulase, xylanase, and amylase activity, i.e., enzymes responsible for phloem digestion. Activity levels of these enzymes were highest in the foregut and their pH optima were around 5. It is not clear whether the cellulase activity is of microbial origin or whether the beetles have cellulases of their own. Protease activity was also present, mainly in the midgut in highly alkaline pH, suggesting that the anterior part of the gut is the major site of polysaccharide digestion in mildly acidic pH, while midgut is the major site of protein digestion in highly alkaline pH.

Interacting disturbances in mixed-conifer forests of the United States: effect of bark beetles and wildfires on forest trajectories. Stevens-Rumann, C., Morgan, P. (*University of Idaho, USA; csrumann@uidaho.edu; pmorgan@uidaho.edu*).

Increasing wildfires and outbreaks of bark beetles in the western United States have led to concern about the impact of multiple disturbances. The objective of this research was to understand the effects of fuels and tree regeneration on large wildfires with and without prior bark beetle-caused tree mortality in mixed conifer forests of the interior northwestern United States. Data were collected from 180 plots across four wildfires that burned in 2007. Both tree seedling density and fuel abundance varied up to 6 years post-fire. Seedling densities were lowest on areas that experienced only wildfire, without bark beetle activity. The most coarse woody debris (logs >7.62 cm) was found on sites that experienced bark beetle activity 3–6 yr prior to study and on sites that experienced a wildfire and previous bark beetle attacks. Areas that experienced both bark beetle-caused tree mortality and a wildfire had higher mean tree seedling densities and woody fuel than areas with wildfires and no prior bark beetle mortality; however, fine woody debris (logs <7.62 cm) did not differ significantly between disturbances. Large snags that are beneficial for wildlife had the highest densities on burned sites, but all disturbances maintained significantly higher snag densities than control sites and well above minimum desired densities for these forest types.

Insect pest problems of Indian sandalwood (*Santalum album* L.) in the current scenario of its cultivation and possible management practices. Sundararaj, R. (*Institute of Wood Science and Technology, India; rsundariwst@gmail.com*).

Santalum album L. is a valuable tree that occupies a preeminent position in Indian forestry. India used to contribute 90% of the *S. album* output of the world, but its share has declined in recent years and sandalwood is now in the vulnerable category of the IUCN Red List. Recognizing this grim situation, state governments of sandalwood-growing states relaxed the rule in such a way that "every occupant or the holder of land shall be legally entitled to the sandalwood tree in his land." Relaxed regulation is encouraging community and private entrepreneurs to cultivate *S. album* in agroforestry, farm forestry, and various agri-silvi-horticultural and mixed plantation systems. Many insect pests of agricultural and horticultural importance were found affecting sandalwood in these new systems of sandal cultivation. Infestation of sucking pests, particularly scales and mealybugs, often causes 30% mortality of trees in the early stage of establishment, and severe infestation of stem borers often causes almost complete failure of plantations. Many pests were found increasing their host range on *S. album.* In light of these findings, the emerging insect pest problems on *S. album* under cultivation and its efficient management practices were discussed in this paper.

Record of two new insect pests on Indian rosewood (*Dalbergia latifolia* Roxb.). Sundararaj, R., Ragavendra, G., Nalini, R (*Institute of Wood Science and Technology, India; rsundariwst@gmail.com; gundi.raghava21@gmail.com; rnalinidsi@gmail.com*).

The rosewood (*Dalbergia latifolia* Roxb.) is an economically important timber species indigenous to India. The timber is used for fine furniture and cabinet making, musical instruments, turnery, and decorative veneers. Medicines and an appetizer are made from tannins in the bark. The species is planted as a shade tree. Thus far it has been reported to be infested by 16 species of wood feeders, 14 species of sap suckers, and one species each of a defoliator and seed feeder. In the present study on insect pests of trees in south India, the mealybug *Icerya* sp. and the weevil *Peltotrachelus pubes* were found infesting *D. latifolia.* The severe

infestation of *Icerya* sp. often resulted in drying and premature falling of leaves. Infestation of *P. pubes* often resulted in complete defoliation of young plants. This is the first report of these two insects being found on *D. latifolia*. In this paper the insect pests so far reported on *D. latifolia* are reviewed and the significance of the occurrence of two new pests on *D. latifolia* is discussed.

Status of the invasive spiraling whitefly *Aleurodicus Dispersus* Russell (Hemiptera: Aleyrodidae) in India along with new host records. Sundararaj, R., Revathi, T.G., Divya, K.P., Amuthavalli, T. (*Institute of Wood Science and Technology, India; rsundariwst@gmail.com; revathi.tg@gmail.com; divyakprabhakaran@gmail.com; t7amutha@gmail.com*).

Whiteflies are small phytophagous insects belonging to the family Aleyrodidae. They infest the leaves of plants, generally the undersurface; a few species are found on petioles and stems. They are mostly restricted to the Tropics and Subtropics. The spiraling whitefly *Aleurodicus dispersus* Russell is an invasive species to India, and the spread of this whitefly was successful mainly due to its polyphagous nature and prolific breeding. In India, it has been found breeding on 320 plant species belonging to 225 genera under 74 families. The major host plants of economic concern in India are banana, guava, avocado, papaya, coconut, cucurbits, dahlia, gerbera, gladiolus, tomato, mulberry, tapioca, and bell pepper, in addition to several species of shade trees in the urban and forest environment. *Tectona grandis, Michelia champaca, Eucalyptus camaldulensis, Eugenia jamboloana*, *Artocarpus heterophyllus*, *Bauhinia variegata*, *Thespesia populnea*, *Pongamia glabra*, and *Polyalthia longifolia* are some of the important tree species affected by this whitefly. Detailed surveys conducted during 2010–13 on the whitefly fauna of India resulted in the discovery of many new host plants and found that *A. dispersus* is increasing its host range. In the light of these findings the pest status and host range of *A. dispersus* in India are discussed.

A simple non-destructive method for detecting heart rot in standing trees using impact resonance frequency Suyama, H. (*Shimane Prefecture Mountainous Region Research Center, Japan; suyama-hiroshi@pref.shimane.lg.jp*).

The decay-area ratios inside the stems of 240 living Japanese black pines in a park in Matsue City, Japan, were estimated using the lateral impact vibration method. Estimates were obtained using the diagnostic index, *df*, which is the product of the diameter *d* of a stem and the resonance frequency *f*, resulting from laterally impacting the stem with a hammer. Initially, the following procedures were performed: (1) The *df* of 31 Japanese black pines was measured using the lateral impact vibration method. These trees were then subsequently cut down to confirm whether the trees had decay. The average *df* of the non-decayed pines was accordingly obtained. (2) Using artificial hollow disks, the relationship between the hollow-area ratios and the decreasing rates of *df* was determined. All the trees in the park were tested using this method. The decay-area ratios were calculated on the basis of the two abovementioned procedures. To evaluate the accuracy of the method, the actual decay-area ratios were measured by cutting. The decay-area ratios estimated by this method were highly positively correlated with the actual ratios ($r = 0.80$, $p < 0.001$). This method was thus shown to be effective in estimating the decay-area ratios inside the stems of Japanese black pine.

A field evaluation of *Metarhizium anisopliae* formulations for management of Ailanthus defoliator, *Eligma narcissus* Cramer. Theeyan Chari Othayoth, S. (*Ashoka Trust for Research in Ecology and the Environment, India; tosasi@atree.org*).

Many planters of South India are currently growing *Ailanthus excelsa* trees because of increasing demand in several wood-based industries. Recently, recurrent defoliation by a lepidopteran pest, *Eligma narcissus*, has been observed severely affecting the productivity of the trees. The efficacy of 25 *Metarhizium anisopliae* isolates against the pest larvae was evaluated through a laboratory bioassay. Two promising isolates, MIS7 and MIS13, were subsequently evaluated in two infested 4-yr-old *A. excelsa* plantations in Odagathur of Tamil Nadu state. Two formulations of the isolates, F1 (MIS7+MIS13 at 1 014 conidia ml/ in 0.08% Tween® 80) and F2 (MIS7+MIS13 at 1 014 conidia ml/1 in 0.08% Tween 80 with 0.5% *Pongamia pinnata* seed oil), were applied by spraying. The population counts of *E. narcissus* were recorded 1 day before and 7 and 15 days after the application. Reduction of pest population over control calculated using the Henderson and Tilton equation was 60.5% in F2 and 53.8% in F1. Results indicate the potential for application of the formulation with *P. pinnata* seed oil to manage *Ailanthus* defoliation risk.

Forest fire danger changes for the China mainland in the last 30 years. Tian, X., Shu, L., Hong, L., Wang, M., Zhao, F. (*Chinese Academy of Forestry, China; tianxr@caf.ac.cn; slfhxk@126.com; work_li@caf.ac.cn; oldchoff@163.com; zhaofengjun1219@163.com*).

It is necessary to identify the effects of climate change on fire regimes for adaptation to climate change. This paper classified fire danger zones for the China mainland based on wildfires detected by satellites in 2005–2012 and ecological zones. A dataset of 824 daily weather observations for 1980–2010 was interpolated into 0.25° × 0.25° grids, and fire danger indexes were calculated for all grids by using the fire weather index (FWI) system. Results showed that: (1) The China mainland can be divided into eight fire danger regions (R1–8) and no vegetation areas, such as the North Daxing'anling Mountains deciduous coniferous forest region (R1), and (2) In 1981–2010 the annual average temperature and precipitation of the China mainland were 6.4 °C and 620 mm, respectively. Precipitation in the 2000s decreased 3.8% and 5.1% compared to the 1980s and 1990s, and the temperature increased 0.9 °C and 0.4 °C, respectively. Precipitation for R1, R2, and R3 declined significantly (8.5–16.0%). (3) FWI showed an increasing trend for most areas, especially for R2, where the FWI in the 2000s increased 29.3% over the 1980s. FWI for R2, R4, R7, and R8 increased by 8.9–14.7%, but the index for R8 decreased by 10.3%.

Assessing the impacts of *Imperata cylindrica* (L.) Beauv on root-feeding bark beetle populations associated with southern pine decline. Trautwig, A., Brunson, B. (*Auburn University, USA; antrautw@gmail.com; bab0002@tigermail.auburn.edu*), Carter, E. (*U.S. Forest Service, USA; eacarter@fs.fed.us*), Eckhardt, L. (*Auburn University, USA; eckhalg@auburn.edu*).

The invasive grass *Imperata cylindrica* is an increasing threat to the diversity of native plant and wildlife species in the United States. Another issue facing landowners of southeastern forests is pine decline (PD). The factors associated with PD include a complex of abiotic and biotic stressors that cause economically significant mortality in *Pinus* forests. Root-feeding bark beetles, which are vectors for pathogenic ophiostomatoid fungi, are attracted to stressed pines. *I. cylindrica* could be contributing to pine decline by inducing additional stresses, leading to higher infestations of root-feeding bark beetles. Twenty plots were established

in a *P. taeda* pine plantation located in southeastern Mississippi (10 with *I. cylindrical* and 10 without *I. cylindrica*). Insect traps on each plot were checked biweekly to observe insect population trends. Data show that *Hylastes salebrosus* was the most abundant species and had consistently higher populations in *I. cylindrica* plots. *Hylastes porculus*, *Dentroctonus terebrans*, and *Hylobius pales* showed similar trends, but populations were not significantly different between treatments. Soil moisture was found to be significantly higher in the top 8 inches of the soil horizon for *I. cylindrica* plots. This result may indicate that *I. cylindrica* rhizomes altered moisture availability to *P. taeda* pine roots and caused additional stress to the trees.

Collaboration in managing the threat of *Sirex noctilio*: the South African experience. Upfold, S., Croft, P., Dyer, C. (*Institute for Commercial Forestry Research, South Africa; sally.upfold@icfr.ukzn.ac.za; philip.croft@icfr.ukzn.ac.za; colin.dyer@icfr.ukzn.ac.za*), Hurley, B., Slippers, B. (*FABI-University of Pretoria, South Africa; brett.hurley@fabi.up.ac.za; Bernard.Slippers@fabi.up.ac.za*), Verleur, M., Wingfield, M.

First detected in *Pinus radiata* in the Cape Province of South Africa in April 1994, the woodwasp *Sirex noctilio* has spread across the pine-growing areas of the country, posing a significant threat to commercial softwood plantations. The South African Sirex Control Programme (SASCP) was established by the forestry private sector to address this threat. The programme became a unique private-public partnership between the private forestry sector, government (Department of Agriculture, Forestry and Fisheries), and specialized research institutions (Forestry and Agricultural Biotechnology Institute (FABI) and the Institute for Commercial Forestry Research (ICFR)).This paper details the approach taken by the South African Forestry Industry, particularly the development of the SASCP, in managing the threat to commercial pine plantation forests from the *Sirex* woodwasp. The history of the programme through to current initiatives is presented, including an overview of operational processes developed to control *Sirex,* the deployment of biological control agents, monitoring to detect the extent and spread of *Sirex*, communication to and awareness by all stakeholders, and research to support the programme. The various roles of all public and private partners are highlighted as are the lessons learned that can be effectively used in the management of future risks.

***Quambalaria*: new reports from four continents, including a new species from Australia.** Wingfield, M., de Beer, W., Marincowitz, S. (*FABI-University of Pretoria, South Africa; mike.wingfield@fabi.up.ac.za; wilhelm.debeer@fabi.up.ac.za; Seonju.Marincowitz@fabi.up.ac.za*), Kolařík, M. (*Academy of Sciences of the Czech Republic; mkolarik@biomed.cas.cz*), Pegg, G. (*Agri-Science Queensland, Australia; geoff.pegg@dpi.qld.gov.au*), Duong, T.

The smut-like genus *Quambalaria* is associated with foliar diseases on myrtaceous trees. The aim of this study was to characterize new isolates from various host trees in Africa, Southeast Asia, the United States, and Australia based on DNA sequences from ITS and EF-1α gene regions. The phylogenies of the two gene regions corresponded well and revealed six monophyletic clades representing *Q. pitereka*, *Q. eucalypti*, *Q. cyanescens*, *Q. coyrecup*, *Q. pusilla* (with *Q. simpsonii* as synonym), and a new species from leaf spots on *Angophora costata* in Australia. The data revealed new host records for *Q. coyrecup, Q. cyanescens*, and *Q. pitereka* from *A. costata* in New South Wales, and *Q. pitereka* from *Corymbia tessellaris* and *C. ptychocarpa* in Queensland. New country reports from diseased *Eucalyptus* leaves include *Q. eucalypti*, *Q. pusilla*, and *Q. cyanescens* from Laos, and *Q. eucalypti* from Thailand. *Quambalaria cyanescens* was the only species on non-myrtaceous hosts and on all inhabitable continents. It is associated with several hardwood-infesting bark beetles from Colorado and California (USA), and from Tunisia. Australia is the only country where all six *Quambalaria* spp. have been reported, suggesting that this is the centre of origin of the genus.

Mapping susceptibility to large forest fires using MODIS in Washington and Oregon (USA). Yang, Z. (*Oregon State University, USA; zhiqiang.yang@oregonstate.edu*), Davis, R., Cohen, W. (*U.S. Forest Service, USA; rjdavis@fs.fed.us; wcohen@fs.fed.us*), Mildrexler, D. (*Oregon State University, USA; David.Mildrexler@oregonstate.edu*).

Mapping fire-prone areas, especially those susceptible to large forest fires, has important implications for forest management as well as wildlife conservation. For example, wildfire has been identified as the leading cause of habitat loss for spotted owl nesting and roosting. This study presents a framework for modeling the probability of large fires in forested areas of Washington and Oregon (USA). The analysis uses environmental gradient, forest successional status, and current forest conditions to map the pattern of large fire occurrence. In addition to static environmental variables, e.g., elevation, slope, and radiation, MODIS land surface temperature is included. It is hypothesized that a stressed forest is more prone to fire. In this analysis, areas with a long-term trend of decreasing vegetation vigor were identified using time series of Landsat images. MODIS surface reflectance and Normalized Difference Vegetation Index (NDVI) products were used to represent current vegetation condition. Random samples from fires as identified by Monitoring Trends in Burn Severity (MTBS) from 2002 to 2010 were used as training data, and predicted fire probability maps for 2011 to 2013 were used for validation. Two modeling methods were evaluated: MaxEnt and Random Forest.

Damage risk assessment of Norway spruce forests with different site and stand characteristics: towards sustainability assessment and sustainable management. Žemaitis, P., Stakenas, V., Čapkauskas, G., Varnagiryte-Kabasinskiene, I. (*Aleksandras Stulginskis University; povilaszemaitis@gmail.com; v.stakenas@mi.lt; gediminas.capkauskas@gmail.com*).

Tree health and frequency of tree damage are key elements influencing the sustainability of forest stands. Therefore, it is very important for forest managers to identify the site types and stand characteristics that can help to reduce the vulnerability of stands. Norway spruce (*Picea abies* (L.) H. Karst.), a dominant tree in the forests of Eastern and Northern Europe, were studied. Data from the Forest Monitoring Level I (1989–2010) data set with approximately 2 000 Norway spruce samples collected annually were used. Humidity and soil fertility were selected as site variables; tree species composition, stand structure, and age were selected as stand characteristics. Total risk index was calculated based on spruce crown defoliation, defoliation class, and frequency of identifiable biotic and abiotic damage (e.g., insects, fungi and diseases, wind, frost, drought). Results showed that site and stand characteristics are important factors in the condition of and damage distribution in spruce stands in Lithuania. The authors concluded that Norway spruce management could be optimized according to the lowest total risk index based on site and stand characteristics.

GENERAL POSTER SESSIONS

IUFRO Division 8: Forest Environment

The roles of protected areas to biodiversity conservation and carbon storage: case study of two developing countries. Adekunle, V. (*Federal University of Technology, Nigeria; adekunlevaj@rediffmail.com*), Nair, N. (*National Botanical Research Institute India; nairnbri@yahoo.co.in*).

The contributions of protected areas (PAs) in two developing countries (Katarnia Ghat Wildlife Sanctuary, India and Eda Strict Nature Reserve, Nigeria) to biodiversity and environmental conservation were assessed in this study. Inventory data were collected from 12 plots (25 m × 25 m) randomly located in each of the PAs. In each plot, all woody plants were identified and tree growth variables (DBH ≥ 10 cm) were measured. Biodiversity indices were used for species diversity, analytical formula for stand volume, and Brown's model for biomass estimation. The diversity and abundance, physiognomy, yield, and the family importance of the PAs indicated that they are mature, repository of biodiversity, and have potentials for continuous development. The biodiversity indices compared favorably with the results from other similar PAs. The above ground biomass and carbon estimation show the roles of forest landscape in climate change mitigation through CO_2 absorption. The difference in phytosociological characteristics and carbon values of the two PAs, higher values obtained for the Nigerian PA, was attributed to the variation in geographical location, climatic conditions, and soil properties. The challenges in developing countries with forest protection can be mitigated by introducing some institutional policies and involving rural communities in the management of PAs.

PES: the watershed services of tropical forest. Adnan`, N., Ahmad, I., Mohd Yusof, M. (*Forest Research Institute Malaysia, Malaysia; norliyana@frim.gov.my*)*; ismariah@frim.gov.my; mohdfaridzul@frim.gov.my*).

Ecosystem services received attention in both the Millennium Ecosystem Assessment and The Economics of Ecosystem and Biodiversity (TEEB). One of the most important ecosystems provided by tropical forest is watershed. Tropical forest resources have been one of the major sources of revenue for the Malaysian economy, however it is decreasing every year due to activities such as commercial logging, shifting cultivation, and forest encroachment for other land uses. The sustainable management practices for watershed and land use have to apply in order to fulfill the demand between watershed and land use, where protecting water resources is communities demand and land use. This study uses both statistical and economic models to understand the impact and the value of tropical forest protection for watershed services. This study is based on 69 catchments of streamflow and sediment monitoring stations of 10 states in Malaysia. For each station we use a geographic information system (GIS) to determine catchment boundaries and to construct catchment-specific meteorological variables. Data on each forest are gathered from the National Forest Inventory from 1982, 1991, 1997, and 2002 while data on nonforest land use are derived from the land use survey maps for 1984, 1990, 1997, and 2004. For the hydrological analysis, we used multiple regression analysis to evaluate the effect of land use changes on water flow and sedimentation in the river basin.

Assessment of tree species diversity and growth analysis of trees species in Igbo-Olodumare, Ondo State, Nigeria. Agbelade, A. (*Federal University of Technology, Nigeria; aladesanmi2008@gmail.com*).

This research paper examines tree species diversity, abundance, and yield of trees species in Igbo-Olodumare, Ondo State, Nigeria. Basically, the objective of this research work was to assess the level of biodiversity and analyze the growth variables of the forest ecosystem. Data were collected from three temporary sample plots of 20 m × 20 m, laid systematically in the sites. Within each plot, trees with DBH ≥ 20 cm were identified and their DBH was measured. Biodiversity indices and growth variables were computed with biodiversity and growth variable equations. There was a total of 152 stems/ha of 17 families and 27 species. Shannon's maximum diversity index (Hmax) was 5.02, Shannon's equitability (EH) was 2.07, and Shannon-Wiener diversity index (H') was 2.66. Tree growth variables were obtained and indicated as mean diameter at breast height (17.82 m), mean basal area (14.0 m^2/ha), and mean volume (87.21 m^3/ha). The most abundant species was *Hildegardia barteri* in the family of Meliaceae (53 stems) followed by *Mansonia altisima* in the family of Sterculiaceae with 13 stems, and *Celtis zenkeri* in the family of Ulmaceae with 8 stems. It is therefore recommended that the forest estate within Igbo-Olodumare should be protected adequately and developed into a world class tourist attraction center with proper forest management in place.

Enhanced accumulation of Hg in aquatic biota: An effect from forestry and land use? Åkerblom, S. (*Swedish University of Agricultural Sciences, Sweden; staffan.akerblom@slu.se*), Eklöf, K. (*Pennsylvania State University, USA; kje15@psu.edu*), Bishop, K., Wu, P. (*Swedish University of Agricultural Sciences (SLU), Sweden; Kevin.Bishop@slu.se; pianpian.wu@slu.se*).

Field studies have been initiated in Sweden with the main focus being to estimate temporal trends of Hg in fish from lakes subject to forestry operations in their catchments. These forestry operations include clearcut as well as fertilization. Results from these studies were compared to temporal trends of Hg in fish from national monitoring stations. Forested catchments accumulate considerable amount of Hg compared to unforested catchments. This excess in stored Hg, primarily in soils, is a source of Hg available for transport and accumulation in freshwater ecosystems. In fact, higher Hg concentrations in fish were found in boreal forest lakes, even in remote areas, compared to unforested areas. Several studies have shown that Hg transport increases in stream runoff after forestry operations. This excess in exported Hg can potentially become available for accumulation in food chains in boreal lakes. It is shown that the direct transport of Hg does not directly promote higher bioaccumulation. Other chemical and biological effects due to forestry can also be induced that affect the potential of Hg to bioaccumulate.

Ethnobotany and structure of natural stands of plant toothbrush species in southern and central part of Benin. Akpona, T. (*Laboratory of Applied Ecology, Benin; ajeandidier@gmail.com*), Akpona, A. (*General Directorate of Forestry and Natural Resources, Benin; akpona@gmail.com*).

Plant toothbrush, wrongly named toothpick, is a shrub species that is considered as a secondary forest product that thrives in natural stands (savannas and forest). A structural description of the stands mainly composed of these species was done through a forest inventory of 19 square plots of 50 m per side. Data collected within plots were the diameter of each individual and the number of the species that were used to compute dendrometric and ecological parameters. Moreover, an ethnobotanical survey was conducted in some districts of south and central Benin through interviews of 105 randomly selected people. Data collected were related to their perception on the patterns of use of plant toothbrush species. The results obtained showed that the density of the plant toothbrush was significantly higher in savannas than in forest, and the species richness was higher in tree-savannah and forest than in shrub-savannah. The other structural parameters had almost the same value in savannas and forest. The most important and most used species were: *Anogiussus leiocarpa, Bridelia ferruginea, Combretum collinum, Hymenocardia acida, Malacantha alnifolia, Napoleona vogelii, Pseudocedrella kotschyi, Sorindea warneckei, Terminalia glaucescens* and *Zantoxylum zanthoxyloides.*

Where will forest loss occur? Identifying attractors of forest loss in temperate ecosystems of south-central Chile. Altamirano, A. (*Universidad de La Frontera, Chile; adison.altamirano@ufrontera.cl*), Miranda, A. (*Universidad de La Frontera, Chile; alejandro.miranda@ufrontera.cl*), Pinchiera, F. (*Corporacion Nacional Forestal, Chile; francoise.pincheira@gmail.com*), Cayuela, L. (*Universidad Rey Juan Carlos, Spain; luis.cayuela@urjc.es*), Orrego, R. (*Universidad de La Frontera, Chile; r.orrego@ufromail.cl*).

Temperate forests of Chile are one of the world's biological hotspots but they are being transformed at an unprecedented high rate. We investigated the attractors of forest loss in three physiographical zones of Chile. We analyzed satellite imagery from 1973, 1987, 1999, and 2008. Multiple logistic regression models were fitted to investigate the relationship between the main trajectories of forest loss and attractors of such change. Overall, a decrease of native forest cover associated to an expansion of agricultural land and establishment of forest plantations. Yet, the trajectories of forest loss were not homogeneously distributed across regions for the different time periods. Whereas in the Coastal and Andean Ranges native forests were mostly replaced by exotic plantations, in the Central Valley agricultural expansion was the main responsible of forest loss. In the Coastal Range, forest loss mainly occurred on flat slopes and next to villages. In the Central Valley, proximity to existing agricultural land was the most important attractor. Finally, forest loss in the Andean Range was associated to lower elevations and flat slopes. Our results highlight the need for new policies to reduce native forest loss that consider the spatial variability of the trajectories and attractors of deforestation.

Integrating data at multiple scales to assess national synergies between forest carbon and biodiversity in Colombia. Armenteras, D., Rodriguez, N., Molina, E. (*Universidad Nacional de Colombia, Colombia; darmenterasp@unal.edu.co; neraso2000@gmail.com; edumolgo@gmail.com*), Retana, J. (*Centre for Ecological Research and Forestry Applications (CREAF), Spain; javier.retana@uab.es*).

Few studies have analyzed the relationship of forest carbon (C) stocks and biodiversity at national and sub national levels in tropical countries. Part of the problem is the lack of adequate data for monitoring both carbon and biodiversity at the local levels. This can be overcome by undertaking a combination of a three tier approach proposed to integrating biodiversity concerns into assessment frameworks for national programs for reducing emissions from deforestation and forest degradation, thus combining globally derived data with nationally generated remote sensing data and ground based forest and biodiversity surveys. In the present study, we apply this combined approach with available datasets at different scales and assess the congruence between forest C storage and biodiversity, focusing on species richness at the national level in a tropical country such as Colombia. We also analyze the variation in this relationship within Colombian regions with highly contrasting geographical characteristics and explore factors that affect biodiversity and C patterns. We analyze areas of maximum biodiversity and of maximum carbon storage to find out geographical areas with overlaps. Finally, we identified those regions potentially to be the focus of either forest carbon or biodiversity focused policies.

Ecosystem response 20 years after intensive forest harvesting for bioenergy in *Betula papyrifera* stands in Central Newfoundland: a multidisciplinary approach. Arsenault, A., Titus, B., Thiffault, E., Baines, P. (*Canadian Forest Service, Canada; Andre.J.Arsenault@NRCan-RNCan.gc.ca; Brian.Titus@NRCan-RNCan.gc.ca; Evelyne.Thiffault@RNCan-NRCan.gc.ca; Patricia.Baines@NRCan-RNCan.gc.ca*), Sveshnikov, D. (*Memorial University of Newfoundland, Canada; dmitry.sveshnikov@grenfell.mun.ca*).

Bioenergy produced from biomass left behind from forestry operations is renewable, reduces fossil fuel use, and has economic potential in Canada. However, it is important to understand the environmental impacts of intensive forest harvesting and use this knowledge to guide policy and develop best management practices to ensure the sustainable management of our forests. We examined forest ecosystem response to conventional and whole-tree harvesting of white birch stands 20 years after treatment along a productivity gradient at three locations in Central Newfoundland. Clear-cutting significantly increased the diversity of vascular plants, most likely because of increased light levels, but the intensity of biomass removals did not appear to affect the abundance or diversity of vascular plant species. However, significant differences in the abundance of deadwood and associated nonvascular flora persisted 20 years after treatment. The combination of clear-cutting and intensive browsing by moose accelerated succession when conifers were abundant in the understory. Sites with low conifer regeneration developed into alder thickets. The intensity of biomass removal did not appear to influence this result, however, the whole tree harvest treatment was associated with lower conifer growth and volume at one of the sites. Relationships between forest structure, species diversity, forest productivity, and soil and foliar nutrients will be discussed within the context of intensive biomass harvesting.

Relation between soil type and potential of regeneration in vegetation pattern of Sudanian zone. Assede, E. Adomou, A., Sinsin, B. (*University of Abomey-Calavi, Benin; assedeemeline@gmail.com; adomouaristide@yahoo.fr; bsinsin@gmail.com*).

Regeneration of woody species has always been the major concern of ecologist in the process of ecosystems renewal. This work aims to determine the potential of regeneration in different vegetation units of the Sudanian zone and establish a relationship with the soil type. A total of 615 square plots of 25 m^2 were established inside of four vegetation patterns. We used Poisson regression

to model the regeneration potential across different soil types. Contrary to floodplains, the border of streams and the hills presented a positive effect on density of regeneration. The incidence rate ratio of floodplains, border of streams, and hills were respectively 1.01, 2.1, and 0.67 times the incident rate ratio of plains. Contrary to hills, floodplains and border of stream had a negative effect on the number of species in regeneration compared to plains. The incidence rate ratio of floodplain, border of stream, and hills were respectively 0.43, 0.6, and 1.2 times the incident rate ratio of plains. From the tree species studied, only *Terminalia macroptera* presented its best regeneration density in floodplains. Even if the soil type was a good predictor of the regeneration potential, it was not sufficient to predict the evolution of regeneration potential.

How to make burning of Chocolate Hills of Bohol, Philippines carbon neutral? Bantayan, N., Pulhin, F., Calderon, M., Predo, C. (*University of the Philippines Los Banos, Philippines; ncbantayan@gmail.com; yaybpulhin@yahoo.com; bargecal@yahoo.com; cdpredo@yahoo.com*), Barruga, R., Barruga, R. (*Ecosystems Research and Development Bureau Philippines, Philippines; roseannbarruga@yahoo.com; roseann_barruga@yahoo.com*).

This study was conducted to develop a carbon offset program for the Chocolate Hills Natural Monument (CHNM) in Bohol, Philippines. We found that the current scheme of burning to maintain the grass-covered (treeless) and brown hills in order to sustain tourist arrivals is environmentally unsound. The study estimated the carbon loss from burning and compared it with the tourism income of the Chocolate Hills. A comparison of the benefits and costs of the status quo and the proposed management regime was conducted. Also, the biomass analysis and the carbon assessment reveal that an estimated 153 ha of forest should be established to offset the carbon emission due to clearing of the hills. This means that the carbon offset project will require the establishment of one hectare of forest for every two hills cleared. The cost of forestation could be supported with income from tourism in a form and manner that directly involves the community. The study found that the present value of tourism income was much higher than the cost of carbon emission due to burning.

Ground beetles (Coleoptera, Carabidae) assemblage in forests plantations of the Colombian Orinoquia. Baquero Carvajal, L., Pinzón Florian, O. (*Universidad Distrital Francisco José de Caldas, Colombia; sptefannie@hotmail.com; opatriciap@udistrital.edu.co*).

Commercial forests plantations with fast growing species such as *Pinus caribaea*, *Eucalyptus pellita.* and *Acacia mangium* are replacing areas previously occupied by natural savannas or introduced pastures in the Colombian Orinoco region. Consequences of changing soil use over associated diversity and soil productivity are still unknown. Considering that Carabidae are sensitive to environmental and structural changes in the ecosystem, and therefore used as ecological indicators of disturbed areas, we compared their richness in stands of *Eucalyptus pellita* and *Pinus caribaea* of four different ages in which silvicultural management was crucial. Sampling was performed exposing 135 pitfall traps for 15 days at the beginning of the rainy season of 2013. Some environmental and dasometric variables were also recorded including closure of the canopy, litter accumulation, and basal area of the trees. A total of ten and nine morphospecies were found in eucalyptus and pine respectively, belonging to five genera of which the most representative was the genus *Tetracha.* In addition, Cicindelinae and Scaritinae were most representative subfamilies. Richness was higher in younger plantations disregarding the forest species.

Designing innovative silvicultural best practices to increase multi-taxa biodiversity in Natura 2000 priority habitats (9210* and 9220*) Apennine beech forests. Barbati, A. (*University of Tuscia, Italy; barbati.sisfor@unitus.it*), Burrascano, S., Sabatini, F. (*Sapienza University of Rome, Italy; sabinaburrascano@gmail.com; francescomaria.sabatini@gmail.com*), Corona, P. (*Forestry Research Centre (CRA-SEL), Italy; piermaria.corona@entecra.it*), Portoghesi, L. (*University of Tuscia, Italy; lporto@unitus.it*), Blasi, C. (*Sapienza University of Rome, Italy; carlo.blasi@uniroma1.it*).

Beech forests of the Appennines priority habitats 9210* and 9220* are remnants of more extensive forests where beech was mixed with European yew (*Taxus baccata*) and/or European holly (*Ilex aquifolium*) and silver fir (*Abies alba*). Nowadays, most of their natural range is represented by almost pure beech stands, with cascading effects on the diversity of plants and other taxonomic groups. The EU funded LIFE+ project FAGUS (Forests of the Apennines: Good practices to Conjugate Use and Sustainability) aimed at testing silvicultural treatments to increase the presence of target trees (yew, holly, and silver fir) in beech habitats and biological diversity of other focus taxa (vascular plants, epiphytic lichens, saproxylic fungi and beetles, birds) while sustaining forest use by local communities (e.g., fuelwood collection, grazing). Under the conceptual framework that looks at forests as complex adaptive systems, we applied an advanced methodological approach to support the design of silvicultural treatments based on: (i) multiscale integrated forest structure and multi-taxa survey to analyze relationships between forest habitat heterogeneity and multi-taxa species diversity; (ii) experimental stand manipulation treatments aimed at increasing forest structural heterogeneity, as a way to enhance diversity levels of other focus taxa; and (iii) BACI experimental approach to assess the responses to the tested treatments.

Evaluation of the climate influence in the forest fire occurrences in the Lichinga district, northern of Mozambique. Batista, A., Mbanze, A., Tetto, A., Koehler, H. (*University of Paraná, Brazil; batistaufpr@ufpr.br; aires.banze@gmail.com; tetto@ufpr.br; koehler@ufpr.br*), Manteiga, J. (*Niassa Forest, Mozambique; manteigax95@gmail.com).*

The aim of this study was to assess the influence of climatic variables (temperature, precipitation, and relative humidity) on the occurrence of fire in forest stands in Lichinga District (northern Mozambique) over a period of 3 years. We analyzed the fire occurrences records in three districts (Lichinga, Lago and Sanga). Data was provided by the Center for Monitoring and Control of Forestry Fires (CCMIF) of the company Chikweti Forest of Niassa, and daily weather data including temperature, rainfall, and relative humidity was recorded at 13 hours by the meteorological station of the Institute of Agronomic Research of Mozambique in Lichinga (IIAM-Lichinga). Meteorological data were tested using regression analysis and the Tukey test. A significant variation in temperature and humidity was observed in both tests. The overlapping of the occurrences of fires and climatic variables suggested a great influence of the climate variables in the occurrence of fires, mainly due to the very long dry periods. In 2010 there was a delay in the fire occurrences due to the rainy season which was slightly longer. September and October were the months that recorded the highest number of fire occurrences throughout the study period.

Variation of FMA fire danger index due to climate change in Paraná State, Brazil, in the period 2010 to 2100. Batista, A., Tetto, A. (*Federal Univeristy of Parana, Brazil; batistaufpr@ufpr.br; tetto@ufpr.br*), Deppe, F. (*Technological Institute SIMEPAR, Brazil; deppe@simepar.br*), Filho, J.D.F. (*State University of Ponta Grossa, Brazil; jvirgens@globo.com*), Grassi, J. (*Federal University of Parana, Brazil; jgrassi@simepar.br*), Grodzki, L. (*Agronomic Institute of Paraná (IAPAR), Brazil; leogrodzki@hotmail.com*).

This research aimed to evaluate the temporal behavior of forest fire danger for the state of Paraná, Brazil in the period from 2010 to 2100. Daily index values were calculated for Monte Alegre Formula (FMA) fire danger index, using the scenarios of the Intergovernmental Panel on Climate Change (IPCC), published in 2007. Two IPCCs scenarios were considered: increase of 1.8 ºC and increase of 4.0 in the average temperature of the Earth by 2100. The results of FMA fire danger index were classified into five danger classes. The simulations for the best scenario showed that there will be no major changes in terms of area for the higher danger classes of FMA. However, for the worst scenario, a significant spatial variation in the analyzed period was noted, and in the very high and extreme classes, values reached 96.89% of the area in 2100. The results allowed us to conclude that, if the predictions of the IPCC are confirmed, there will be an increase in the number of wildfires in the state of Paraná, which will require integrated actions to prevent and suppression forest fires to minimize possible environmental, social, and economic losses.

Island size, isolation, and forest ground beetle (Coleoptera: Carbidae) diversity on the fire-prone landscape of Lac La Ronge. Bell, A. (*University of Alberta, Canada; ajbell@ualberta.ca*), Phillips, I. (*Water Security Agency, Canada; iain.phillips@wsask.ca*), Waite, E. (*Saskatchewan Wildlife Federation, Canada; ed.waite@botany.otago.ac.nz*), Nielsen, S., Spence, J. (*University of Alberta, Canada; scottn@ualberta.ca*), (*Univeristy of Alberta, Canada; jspence@ualberta.ca*).

The theory of island biogeography holds that the number of species present on an island is influenced by its size and distance from mainland. Large islands are typically more diverse because they have more resources and niches, in addition to supporting larger populations with reduced risk of local extinction. Similarly, islands near the mainland are typically more diverse on account of increased probabilities of colonization. However, the role of natural disturbances, such as wildfire, on island biogeography is not fully understood. In the boreal forest, the probability of lightning strikes increases with island size, while the probability of embers from distant fires landing on an island decreases with isolation. The purpose of this study is to (1) investigate changes in carabid beetle diversity between mainland and islands; (2) determine if island size, distance from mainland, and fire history influence carabid diversity; and (3) contrast the proportion of flightless species on the mainland with islands to compare colonization strategies across island characteristics. To evaluate these questions, we used pitfall traps to sample five mainland sites and 30 islands across a size and isolation gradient.

Termite richness in *Pinus caribaea* Muell. plantations in the Colombian Orinoquia. Beltrán Díaz, M., Pinzón Florian, O. (*Universidad Distrital Francisco José de Caldas, Colombia; alrja.rg@gmail.com; opatriciap@udistrital.edu.co*).

Termites are one of the most abundant groups of invertebrates in tropical savanna soils, having important ecological roles in cellulose degradation as well as in the improvement of the physicochemical characteristics of the soils. In order to estimate and compare specific as well as functional termite richness, we sampled in stands of different ages of *Pinus caribaea* established in lands previously occupied by natural savannas and introduced pastures in the Casanare department in the Colombian Orinoco region. Termites were sampled using the standard transect protocol. In addition, environmental (soil type, pH, moisture) and dasometric (basal area, tree height) measures were recorded. Termites collected in soil samples, mounds, and pieces of wood were identified to genus and species level and then classified by trophic group. Thirteen genera grouped in xylophages, humívorous, and intermediates were found. Humivorous termites were found in all plantations disregarding age or thinning. The establishment of *P. caribaea* plantations favors the occurrence of genera of intermediates and xylophagous such us: *Microcerotermes*, *Nasutitermes*, *Neocapritermes*, *Termes*, and *Rhinotermes marginalis*, common in gallery forest of this geographical region.

Flowering and fruiting phenology and floral visitation of four native tree species in the remnant moist Afromontane forest of Wondo Genet, south central Ethiopia. Beshawored, M., Isotalo, J. (*University of Helsinki, Finland; mamokeb@gmail.com; jarko.isotalo@helsinki.fi*), Valtonen, A. (*University of Eastern Finland, Finland; annu.valtonen@uef.fi*).

The flowering and fruiting phenology of four native tree species and their floral visitation by insects was investigated to understand their phenological pattern and the species richness and pattern of visitation. In the natural forest of Wondo Genet, Ethiopia, 25 mature individuals of four indigenous species were selected and monitored over 2 years for their phenology. Flower visiting insects were trapped with sweep nets at an interval of every 2 hours between 8:00–18:00 for 20 days. Circular statistics were employed to test for seasonality in flowering and fruiting. The visitor community compositions of the four species were compared with permutational ANOVA. While the tree species expressed synchronous seasonal flowering that peaked during the dry period, fruiting was also seasonal. The mean monthly rainfall and temperature significantly correlated with the periods of the phenophases. Visitor communities of *M. ferruginea* differed significantly from visitor communities of *A. abyssinicus, P. fulva* and *S. guineense.*

Forests and the hydrological regime: what can we tell policy-makers about how changing tree cover influences runoff. Bishop, K. (*Swedish University of Agricultural Sciences (SLU), Sweden; Kevin.Bishop@slu.se*), Creed, I. (*University of Western Ontario, Canada; icreed@uwo.ca*).

The influence of forests on the hydrologic regime has been investigated and debated over the past century. But the question remains: Do we know enough about how the water regime reacts to changes in forest cover to make water-wise decisions? Afforestation, deforestation, harvest methods, species selection, drainage, and other silvicultural alternatives facing individuals, communities, and governments involve difficult tradeoffs where knowledge of the implications for water should be considered. The author of this abstract will be convening a 2013 AGU fall meeting session with the title of this abstract-Forests and the hydrological regime: after all these years what can we tell policy makers about how changing tree cover influences runoff. The intention of this presentation to IUFRO 2014 is to highlight the major findings, agreements, and conflicts raised by the 20 papers presented at the AGU session which address the complex nexus of interactions between forests and runoff. Particular focus will be placed on the role of spatial scale and the ecoregion in making sense of the often conflicting views on how forests influence hydrology.

Phenological evaluation of five commercial forest species of ecological importance in the forests of the Department of Tolima, Colombia. Bonilla Vargas, J., Lozano Botache, L. (*Universidad del Tolima, Colombia; forest.lorena@gmail.com; llozano@ut.edu.co*).

Based on the forest management principles applied in the Department of Tolima, Colombia, the regional environmental authority Cortolima and the University of Tolima, we present preliminary results of a study that is aimed at getting to know the phenological importance of the following five native forests species: *Quercus humboldtii*, *Tetrorchidium boyacanum*, *Alfaroa colombiana*, *Cedrela odorata,* and *Endlicheria sp*. These species show a certain degree of vulnerability and are on the list of species of high commercial value for the Department. Monthly records were collected using the methodology of Fournier (1974). Six phenological variables have been evaluated: flower bud, open flower, green fruit, ripe fruit, leaf shedding, and leaf sprouting. Each individual has been geo-referenced and encoded on the stem. This study shows preliminary results of a period of 5 years, starting in 2008, including dendrophenograms and phenological calendars for each species of interest. This information will be used for decision making with regard to the planning of forest operations on local and departmental levels. However, at least 10 years of monthly measurements are necessary in order to cover all phenological events during local climatic fluctuations.

Response of small individuals of hardwood species to surface fires in western Chaco region, Argentina. Bravo, S. (*Universidad Nacional de Santiago del Estero, Argentina; sandrabrav@gmail.com*), Kunst, C. (*Instituto Nacional de Tecnología Agropecuaria, Argentina; ckunst@santiago.inta.gov.ar*), Leiva, M. (*Universidad Nacional de Santiago del Estero, Argentina; martaleiva@gmail.com*), Ledesma, R. (*Instituto Nacional de Tecnología Agropecuaria, Argentina; rledesma@santiago.inta.gov.ar*).

The objective of this work was to assess the response to surface fires of juvenile individuals (DBH $\leq$ 15 cm) of three hardwood species from Argentine Chaco, *Aspidosperma quebracho-blanco*, *Schinopsis lorentzii* and *Ziziphus mistol.* We characterized thickness and density of bark of the three species, and we conducted field work in 2008 and 2009 with prescribed burns applied at different times throughout Chaco region's fire season. We determined charring height of bole, mortality, and post fire resprouting pattern. Species and the interaction year of burning* species* timing of burn had significant effects. *A. quebracho-blanco* showed a greater charring height of bole than *S. lorentzii* and *Z. mistol,* and it was the thickest and lowest density bark species. The other two species had lower bark thicknesses and higher densities of bark than *A. quebracho-blanco*. Four months after fires, the mortality was 5% for *A. quebracho-blanco*, 8% for *S. lorentzii,* and 10% for *Z. mistol,* and differences among species were significant. The type of sprouting varied significantly among species, with *A. quebracho-blanco* exclusively producing basal resprouts and the other species producing both epicormic and basal resprouts. The species showed a high tolerance to medium and high severity surface fires in the juvenile state.

Biomass and carbon sequestration of selected natural mangrove forests in the Philippines. Breva, L., Castillo, J. (*Ecosystems Research and Development Bureau (DENR, Philippines; alcala_breva99@yahoo.com; allan536@yahoo.com*).

This study was conducted to determine the biomass, carbon stored in the biomass and sediment, and carbon sequestration rate in selected natural mangrove forests in the country. Quadrat sampling technique and existing mangrove allometric biomass models were used. Results showed that in natural stands, the total biomass ranged from 61 to 478 ton/ha with a mean of 229 ton/ha. The carbon stock in the biomass ranged from 28.81 to as high as 224.66 t C/ha or 107.81 t C/ha on the average. The sediment carbon ranges from 133.8 to 191.27 t C/ha or 154.93 t C/ha, on the average. The total carbon stock in biomass and sediment combined was 262.66 t C/ha, on the average, and ranged from 178.41 to 369.70 t C/ha, which is equivalent to 963.95 ton/ha of carbon dioxide, on the average. The carbon sequestered during the 2-year duration of the study based on biomass accumulation in four natural mangrove stands studied is 3.83 t C/ha/year, on the average and ranged from 1.90 to 5 t C/ha/year. This amount was equivalent to an annual uptake of 14.05 tonnes of carbon dioxide per hectare from the atmosphere. The total carbon stored annually of the mangroves studied was a significant amount which must be managed well in order not to release carbon back to the atmosphere.

Wood anatomy and dendroclimatological potential of trees of the dry tropical forests of Colombia. Briceño, A. (*National University of Colombia, Colombia; bricenoan@gmail.com*), Bogino, S. (*State University of San Luis, Argentina; stellabogino@gmail.com*), Rangel-Ch, O. (*National University of Colombia, Colombia; jorangelc@gmail.com*).

Dry tropical forests of Colombia are of outstanding value due to their high support of the human population and their phytosociological diversity which is higher than that of wet forests. Dendrochronological studies have only more recently been done in tropical areas compared to temperate ones because of their high value and interest in understanding the growth-climate association under changing climate conditions. Mean annual rainfall is about 475.3 mm distributed in two periods throughout the year. Dry periods motivate dormancy in the cambium activity that results in tree-ring formation. Wood anatomy characteristics of tree rings of *Bursera simaruba* (L.) Sarg., *Prosopis juliflora* (L.), *Ruprechtia ramiflora* (Jacq.) CA Mey., *Cordia colloccoca* L., and *Aspidosperma polyneuron* Müll. Arg. growing in dry areas of the Colombian Caribbean are described. Standard methodology for wood anatomy studies was applied. Results showed that *Bursera simaruba, Ruprechtia ramiflora*, *and Aspidosperma polyneuron* tree rings were delimited by woody density variations; however, *Ruprechtia ramiflora* showed lenses or false tree rings. *Prosopis juliflora* and *Cordia colloccoca* tree rings were determined by banded marginal parenchyma. These results allowed us to conclude that *Bursera simaruba*, *Prosopis juliflora*, *Cordia colloccoca*, and *Aspidosperma polyneuron* have an accurate dendrochronological potential for dry tropical forest studies.

Studying deep root dynamics with disaggregation modelling using SIMILE: fine root dynamics for an east central Amazonian moist tropical forest. Briceño-Elizondo, E. (*Instituto Tecnologico de Costa Rica, Costa Rica; ebriceno@itcr.ac.cr*), Christoffersen, B. (*University of Arizona, USA; bradleychristo@gmail.com*), Espeleta, J. (*University of Washington, USA; jfespeleta@gmail.com*), Arias, D. (*Instituto Tecnologico de Costa Rica, Costa Rica; darias@itcr.ac.cr*).

The belowground carbon pool contributes largely to the carbon balance of forest ecosystems, being particularly dynamic in terms of decomposition rates and carbon recycling to the soil carbon, but this pool is often under studied. In many studies, root

sampling has only taken place to a depth of 1–2 m, excluding potential large quantities of carbon and its distribution. Process-based models of forest ecosystems synthesize a broad array of processes from tree physiology, nutrient recycling, soil physics, and chemistry. The modeling environment SIMILE uses disaggregation modelling in which the soil can be divided into a number of layers, aiding the understanding of the demography of root dynamics at different depths, and integrating minirhizotron data sampling information for each layer, using differential equations to define the rate of recycling of each root defined biomass pool. The present research work collected data from belowground measurements in two deep soil pits (10 meter depth), one in closed canopy forest and another in an adjacent natural tree-fall gap. Minirhizotron data aims to integrate object based modeling with state of the art soil profile information on root depth and dynamics to create an accurate model to aid in the soil carbon balance of tropical forest ecosystems.

The impact of a changing climate on net primary production of Mediterranean forests in southwest Western Australia. Brouwers, N. (*Murdoch University, Australia; n.brouwers@murdoch.edu.au*), Coops, N. (*University of British Columbia, Canada; nicholas.coops@ubc.ca*), Hardy, G. (*Murdoch University, Australia; g.hardy@murdoch.edu.au*), Matusick, G. (*The Nature Conservancy, USA; gmatusick@tnc.org*).

Climate conditions in Mediterranean ecosystems have been predicted to undergo significant changes in the future. The southwest of Western Australia (SWWA) is considered a global guinea-pig with regards to impacts of climate change on forest health and function. The SWWA has experienced an average decrease in rainfall since the 1970s along with temperature rises of 0.15 °C per decade over this period. As a result, a number of endemic forest tree species have been undergoing significant declines in health and mortality since the early 1990s. This work reports on a study that used a time-series analysis approach using Net Primary Production (NPP) as an indicator of forest health. MODIS satellite imagery from 2000–2011 was used to look at trends in NPP for the SWWA. Climate data was used to find potential relationships between trends in temperature and rainfall and the observed trends in NPP. This study revealed that between 2000–2011, NPP mainly declined in the transition zone between tree-dominated vegetation and shrublands. We further explore the potential relationships with the climatology and the implications for the future forests in the SWWA.

A sustainability assessment of wood-energy-supply-chains based on the method of a life-cycle-assessment. Brunsmeier, M., Becker, G., Schweier, J. (*University of Freiburg, Germany; martin.brunsmeier@fobawi.uni-freiburg.de; gero.becker@fobawi.uni-freiburg.de; janine.schweier@fobawi.uni-freiburg.de*).

This study concentrates on a sustainability assessment of wood-energy-supply chains with a focus on split logs, wood chips, and wood pellets. The research is based on the method of life-cycle-assessment and evaluates the environmental impacts as well as the economic and social benefits of the products and their use for energy purposes. The three wood-energy products and their energy potential are modeled on the basis of case studies in Germany. All processes within the wood-energy-supply chain, i.e., harvesting of logs, production of the named wood-energy products, transportation and their conversion to energy, are included in the assessment. The results are compared based on selected criteria which include energy efficiency, production costs, and effects on employment, as well as ecological effects like greenhouse gas emissions, acidification, and eutrophication. For the study, 1 kilowatt-hour of thermal energy produced by the wood energy products is defined as the functional unit. Sensitivity analyses reveal differences in the impacts on the environment and production costs as a consequence of alternative technical and organizational solutions of the investigated chains. The results allow a holistic comparison of the sustainability of different wood energy products.

Understory ferns and lianas as indicators of the conservation status in remnants of Brazilian Atlantic rain forest. Cardoso-Leite, E., Castello, A.D., Coelho, S. (*Federal University of San Carlos, Brazil; cardosoleite@yahoo.com.br; caroldcastello@gmail.com; samucabeca@hotmail.com*).

The creation of protected areas (PA) is the main strategy to conserve biological diversity. Government agencies need to monitor biodiversity, and indicators can be used as a tool for monitoring. Biodiversity is too complex to be measured and quantified, therefore the research of ecological indicators is required. Vegetation is considered an indicator for the state of conservation because it responds relatively quickly to environmental changes. Accordingly, our aim was to evaluate if the understory, lianas, and ferns can be used as indicators of the state of conservation in remnants of Atlantic Rain Forest. We analyze two areas, area 1 considered more conserved (within PA) and area 2 considered less conserved (outside PA). We allocated 14 plots of 20 m × 20 m to sample ferns and lianas, and transects of 2 m × 20 m in the center of the main plots were used to sample the understory. Most of the individuals of *Euterpe edulis* were sampled in area 1, i.e., old growth forest. *Hevea brasiliensis*, considered exotic in the Atlantic Rain Forest, was found in area 2, indicating the degradation of this remaining area. The ferns of greater height and lianas with larger diameter were found mostly in area 1, remnants in advanced successional stage, therefore, indicating well-preserved remnants.

Spatial and temporal change of litterfall in the Nanjenshan Lowland Rain Forest, Taiwan. Chen, J. (*National Pingtung University of Science and Technology, China-Taipei; zzz.john@msa.hinet.net*), Wu, S. (*Shih Chien University, China-Taipei; st.wu@msa.hinet.net*), Chen, C., Wei, C., Kuo, C. (*National Pingtung University of Science and Technology Pingtung, China-Taipei; cct@mail.npust.edu.tw; andy3520@gisfore.npust.edu.tw; kawakamii01@gmail.com*).

Lowland rainforests consist of abundant wildlife species and complex components. Litterfall is an important source of nutrition for the lowland rainforests without any artificial management. The litterfall has been an important parameter in ecological research for decades because it can help to understand the function and structure of an ecosystem, and to estimate forest productivity, regeneration, and biomass as well. To analyze the variation of litterfall based on the effects of seasons and weather disturbance, the data used in this study consisted of the measurements of the litterfall quantity and variety from 2004–2012. The results showed that the average quantity of litterfall was 4.91±1.86 t/ha/yr in the past 9 years. The seasonal pattern of litterfall could be divided into summer and winter peaks. Plant litter was mostly composed of leaves (65%), followed by twigs (22%), and flowers and fruits (13%). Different terrains in Nanjenshan area had different quantities and types of litterfall.

Environmental responses and biophysical controls over transpiration by stands/trees subject to urban, suburban, and semi-arid environmental conditions. Chen, L., Zhang, Z. (*Beijing Forestry University, China; myclover17@gmail.com; 122283586@qq.com*).

The objective of this study was to compare the transpiration (E_c) responses to environmental factors under urban and natural conditions. Therefore, our study adopted Granier-type probes to monitor stand/tree transpiration in urban, suburban, and semi-arid natural conditions. We found isohydraulic control over transpiration across species based on the fact that species observed the 0.6 ratio between the sensitivity of canopy conductance to *VPD* and reference G_c under all environmental settings. Therefore, E_c can be estimated reliably based on the accurate canopy conductance measurement under 1 kPa and concurrent meteorological data. But species differences can not be obscured. Trees under urban conditions tended to have stronger transpiration coupling with the atmosphere. Different from those growing in urban and suburban surroundings, trees in a semi-arid environment failed to maintain E_{cmax} when stressed by high *VPD*. No significant decrease was observed for trees during the rainless intervals under all environment conditions. But unlike in semi-arid environment, transpiration of trees in urban and suburban surroundings grew with frequent large rainfall (>30 mm/event). Post-rainfall transpiration recovery results indicate that changes of the rainfall characteristics (scale and frequency) will lead to variation of vegetation cover under natural conditions.

The season, severity, and frequency of prescribed fire shaping the community dynamics of heathland shrub species. Chick, M., Cohn, J., Nitschke, C., York, A. (*University of Melbourne, Australia; mchick@student.unimelb.edu.au; janet.cohn@unimelb.edu.au; craign@unimelb.edu.au; alan.york@unimelb.edu.au*).

Throughout the fire prone regions of the world, the threat of wildfire is being met through increasing both the temporal and spatial components of prescribed burning, meaning the frequency is increasing and the seasonality and severity are altered. Within Victoria, Australia, fire management practices are such that fire prone communities, such as heathland, will experience prescribed burning across a larger range of age classes and at higher frequencies into the future. This research will be focusing on the ecological responses of shrubs in the heathland community to time since last fire (TSLF), the season (spring versus autumn) and severity of prescribed fire, and how these responses vary geographically across a precipitation gradient. This will occur retrospectively through the assessment of TSLF shrub species dynamics, presently through building predictions of community responses when prescribed fire is introduced into these different TSLF dynamics, and into the future through modeling community responses to alternate seasons of prescribed fires with the use of fire scenario modeling. To obtain these objectives, data collected will parameterize the landscape dynamics model LANDIS-ii. Through this research better understanding of the relationship between climate, fire regimes, and shrub dynamics in heathland will be developed.

Stand transpiration estimated by sap flow measurements in a mixed broadleaved forest, western Japan. Chiu, C. (*Kyushu University, Japan; ccwei97@gmail.com*), Komatsu, H. (*Kyoto University, Japan; kmthkr@gmail.com*), Kume, T. (*National Taiwan University, China-Taipei; kumett@ntu.edu.tw*), Otsuki, K. (*Kyushu University, Japan; otsuki@forest.kyushu-u.ac.jp*).

The amount of water used by trees has been widely researched for more than 100 years, and several studies have mentioned that forest types can affect the hydrological cycle of watersheds. Now more than 45% of the forest area in Japan is covered by natural broadleaved forests and most of them consist of mixed forests. However, rare studies have examined variations in sap flow among different types of forests which prevented researchers from estimating canopy transpiration on the basis of the sap-flow method. As a starting point to establishing a method to estimate canopy transpiration based on tree transpiration measurements on the basis of the sap-flux method, we evaluated stand transpiration of a temperate mixed broadleaved forest in Kyushu Island, western Japan. On the other hand, from the viewpoint of water resource management, it is commonly believed that conifer forests have relative higher annual evapotranspiration than broadleaved forests in Japan. To confirm this assumption, we will use data from previous studies which have estimated transpiration of a conifer forest near our study site to compare with our data.

Insect diversity and conservation of Nurod Urod Forest Reserve in Sabah, Malaysia. Chung, Y., Ibrahim, N., Richard, M., Yukang, J., Reuben, N. (*Sabah Forestry Department, Malaysia; arthur.chung@sabah.gov.my; nurulaqidah.ibrahim@sabah.gov.my; richard.majapun@sabah.gov.my; John.Lee@sabah.gov.my; reuben.nilus@sabah.gov.my*).

An insect diversity survey was carried out in June 2012 in Nurod Urod Forest Reserve. Located at the southern part of the Malaysian Sabah in Borneo, the upland mixed dipterocarp forest covers an area of 1 705 hectares. Nocturnal insect diversity was moderately high when compared to other forest reserves surveyed in the past. The Bornean endemics recorded during the survey were four moth species and two damselfly species, namely *Adites hosei, Amata egenaria, Auriculoceryx pterodactyliformis,* and *Lygniodes schoenbergi* (moths); *Rhinocypha aurofulgens* and *Rhinagrion elopurae* (damselflies). As no other insect survey has been conducted in this forest reserve in the past, this pioneer data serves as baseline information for future research work. The endemic, rare, and interesting insect species recorded during the survey provide salient information to enhance the conservation of this forest reserve as well as to provide input for the preparation of a forest management plan. Threats and recommendations to enhance the biodiversity are also discussed.

Climate signals derived from day-to-day analysis: climate sensitivity of *Picea abies* in Northern Italy (Trentino, Eastern Alps). Cocozza, C., Palombo, C (*University of Molise, Italy; claudia.cocozza@unimol.it; caterina.palombo@unimol.it*), Anichini, M. (*Trees and Timber Institute (IVALSA), Italy; anichini@ivalsa.cnr.it*), Tognetti, R. (*University of Molise, Italy; tognetti@unimol.it*), Giovannelli, A. (*Trees and Timber Institute (IVALSA), Italy; giovannelli@ivalsa.cnr.it*), La Porta, N., Emiliano, G.

The intra-annual dynamics of wood formation were used to describe seasonal changes in xylem differentiation phases and to calculate the timing of cell development in Norway spruce (*Picea abies* (L.) Karst.). Tree-ring dynamics of Norway spruce from two altitudinal limits were studied to detect climate signals in the day-to-day dynamics of wood formation. The investigation was conducted during the years 2011–2012 in Trentino-South Tyrol (eastern Italian Alps), in two sites, Savignano (650 m a.s.l.) and Lavazè (1800 m a.s.l.). The climate is subalpine-continental type with a solstitial pluvial curve (maximum values in summer and minimum values in winter). Dendroclimatological analysis was performed to examine the relationship between the tree rings formation of Norway spruce and climatic parameters in the study sites. Climate–growth relationships were analyzed using

correlation function (CF) analysis and moving CF (MCF), detecting correlations between wood formation and seasonal patterns of temperature and precipitation. During the monitored years, the effects of climatic variables on cell structure and stem diameter variation were examined daily. Cell structure was investigated through microscope analysis, and stem diameter variation was detected with microdendrometers. The results were interpreted according to dynamics of forest vegetation and synchronicity of cambial activity.

Saproxylic Diptera biodiversity and intensive biomass harvesting. What are the implications of a damaged deadwood profile? Deady, R., Work, T. (*Université de Québec à Montréal, Canada; mycetophilid@gmail.com; work.timothy@uqam.ca*), Venier, L. (*Canadian Forest Service, Canada; lisa.venier@nrcan-rncan.gc.ca*).

Residual forest biomass in the form of fine and coarse woody debris continues to be proposed as a sustainable source of energy that will reduce dependence on fossil fuels. Biomass harvesting drastically transforms the deadwood profile. Saproxylic Diptera (true flies) like the Sciaroidea is likely affected by changes in deadwood and fungal communities. We will compare saproxylic Diptera assemblages in coarse woody debris (CWD), fine woody debris (FWD), and stumps using emergence traps. We will use Dipteran assemblage differences to: (1) assess whether per unit volume FWD of Jack pine (*Pinus banksiana*) wood is more conducive to speciose and abundant communities than CWD; (2) test how intra-log CWD variation affects saproxylic Diptera assemblages; and (3) examine whether residual stumps act as persistent refuges for biodiversity after removal of biomass. Approx. 500 Sciaridae specimens have been identified to date of 40 species. Preliminary ordinations and GLMs show a slight though significant demarcation between advanced decay assemblages versus early decay assemblages, which may be more apparent with more sampling. Diameter appears to be an important variable despite using provisional data. We are using this information to quantify thresholds of deadwood retention under biomass harvesting and integrating Sciaroid biology into applied forest management.

Response of ground-beetle (Carabidae) assemblages to harvest and wildfire in lodgepole pine forests of western Alberta, Canada. Del Bel Belluz, V., Spence, J. (*University of Alberta, Canada; vbelluz@gmail.com; jspence@ualberta.ca*), Langor, D. (*Canadian Forest Service, Canada; david.langor@nrcan-rncan.gc.ca*).

Ground-beetle assemblages that occupy forests regenerating after harvest differ between stands of various age classes. Such differences have been attributed to differential habitat preferences, and species have been categorized as generalists and specialists in both open-habitat and mature forest. This study explores how assemblages have changed in lodgepole forests near Hinton, Alberta up to c. 60 years post-harvest, and explores potential differences between assemblages from forests regenerating, respectively, after fire and harvest disturbance. Results will increase the understanding of how effects of human harvest may change beetle assemblages in Albertan forests as compared to the natural disturbance of wildfire.

The influence of thinning on tree-water relations in an Aleppo pine forest in Valencia, Spain. Del Campo, A. (*Universidad Politécnica de Valencia, Spain; ancamga@upv.es*), Fernandes, T. (*Federal University of Acre, Brazil; tjgfernandes@yahoo.com.br*), Molina, A. (*Institute of Agrifood Research and Technology, Spain; amolihe@gmail.com*), Herrera, R. (*Venezuelan Institute for Scientific Research (IVIC), Spain; potoy@hotmail.com*).

Thinning of trees may be useful to improve growth rates and to change water fluxes, which are desirable outcomes when managing forests in semiarid water-limited environments. In these conditions, the need to implement proactive adaptive silviculture is widely recognized. The effect of thinning on tree-water relationships (transpiration and soil water content) and growth (basal area increment (BAI), determined through dendrochronological procedures) was investigated in 55-year-old Aleppo pine trees thinned at three different intensities plus a control. Tree growth was significantly enhanced after thinning, with an annual BAI four-fold that of the pre-thinning value and a lower dependence of growth on climate fluctuations (rainfall variability). The sap flow velocity (v_s) in thinned and control trees revealed different functionality of the sapwood. Higher values of v_s (3.59 cm/h) were observed in the thinned trees due to the improved soil water content, whereas it dropped off much more rapidly in the control trees due to lower functionality of sapwood (poorer site conditions). Tree transpiration in the study year reached 6 768 litres per tree in the heaviest intensity thinning. Combined dendrochronology and hydrology methods have proven to be useful in the study of the effects of hydrology-adaptive silviculture in semiarid Mediterranean forests.

Eddy-covariance-based estimates of carbon balance in two tropical seasonal forests in Thailand. Diloksumpun, S. (*Kasetsart University, Thailand; sapit.d@ku.ac.th*), Panuthai, S. (*Department of National Parks, Wildlife and Plant Conservation, Thailand; newsam@3bbmail.com*), Suansawan, C. (*Kasetsart University, Thailand; chatuphon_32@hotmail.com*).

The eddy covariance technique ascertains the exchange rate of CO_2 across the interface between the atmosphere and a plant canopy by measuring the covariance fluctuations between vertical wind velocity and CO_2 mixing ratio. Meteorological parameters were also measured for understanding the environmental conditions for ecosystem carbon cycle. To compare carbon balance of two contrasting tropical forests in Thailand, dry evergreen (DEF) and deciduous (DF) forests, net ecosystem exchange (NEE) was estimated and the choice of a friction velocity (u^*) correction for the estimation of flux on calm nights and other corrections were applied for data quality control. The change in NEE as a function of the u^* threshold was marked, and some of the measured nocturnal data were eliminated by using the 0.4 and 0.25 m/s u^* threshold for DEF and DF respectively. Data gaps were filled with linear interpolation, mean diurnal variation, and nonlinear correlation with temperature and photosynthetically flux density. The seasonal pattern of CO_2 exchange and effects of its factors was evident. The 2-year mean annual NEE from 2010 to 2011 was −2.68 and −3.62 Mg C/ha/yr respectively, reflecting differences in carbon gain in these two forests.

Mammal trade for zootherapeutic and mythic purposes in Benin (West Africa): capitalizing species involved, provision sources, and implications for conservation. Djagoun, C. (*Laboratory of Applied Ecology, Benin; sylvestrechabi@gmail.com*), Akpona, A. (*General Directorate of Forestry and Natural Resources, Benin; akpona@gmail.com*), Mensah, G. (*National Institute of Agricultural Research of Benin (INRAB), Benin; mensahga@gmail.com*), Nuttman, C. (*Topical Biology Association, United Kingdom; cvn22@cam.ac.uk*).

In Benin, in spite of the existence of intense commercial dealings with wildlife for medicinal purposes, no official statistics on the use of animals for medicinal and magic/religious purposes are available, and consequently are taken into consideration even less in laws, decision making processes, and conservation strategies. This study highlighted the global importance and the conservation implications of the use of mammal species in traditional folk medicines. Among the 194 mammal species traded on the traditional medicine market in Benin, 46 were most common. Different threat categories were represented including rare, vulnerable, and threatened species. Moreover, it was noticed that the provision source of animals was not limited to Benin area since some species not listed in Benin fauna are identified on the markets. This study suggested that the more rare the species, the more costly it is. This constitutes an economic motivation for sellers who develop strategies for the availability of threatened species on their displays. Urgent conservation actions are needed to reduce the pressure that this activity sector might cause to biodiversity lost. Moreover, an analytical and operational basis is necessary to guide the forestry and wildlife agencies to consider animal based medicine in the conservation strategies, politics, priorities, and laws.

Application of cost-benefit analysis to estimate the value of the protection function of forests against rockfall. Dupire, S. (*National Research Institute of Science and Technology for Environment and Agriculture, France; sylvain.dupire@irstea.fr*), Bruciamacchie, M. (*National School of Rural Engineering, Water Resources and Forestry (ENGREF) and National Institute for Agricultural Research (INRA), France; max.bruciamacchie@agroparistech.fr*), Berger, F. (*National Research Institute of Science and Technology for Environment and Agriculture, France; frederic.berger@irstea.fr*).

A complex methodology has been implemented to adapt cost-benefit analysis to the interaction between rockfall hazard and mountain forests. It has been tested on six pilot areas situated in the Alps in France, Italy, and Switzerland. Starting from a precise field data collection, it combines the use of GIS software, databases and a tool developed specially to assess the economical calculation. This work allows giving an economical value for the protection function offered by the presence and the management of forests according to two different economical approaches: the substitute cost method and the damage cost avoided method. Results confirm the utility of forests against rockfall and their specific management to face this hazard. This is particularly true when: (1) the length of forest on the slope is important, (2) rockfall threatens a linear issue (roads, railways, etc.), or (3) when issues are of low economic importance. This study also shows the complementarity relevance between forest and rockfall nets. In most cases, especially when threatened issues are homes and human lives, forests cannot ensure sufficient protection, and rockfall nets or embankments are needed. However, the presence of forests allows a reduction in their size so cost is reduced.

Fate and transport of mercury in watersheds: hot-spots and hot-moments in Pennsylvanian watersheds. Eklöf, K., Boyer, E., Drohan, P., Iavorivska, L., Chen, Y. (*Pennsylvania State University, USA; kje15@psu.edu; ewb100@psu.edu; pjd7@psu.edu; lui100@psu.edu; yongsheng@psu.edu*).

The increased input of anthropogenic mercury (Hg) in the environment has led to an accumulation of Hg in soils as well as in the aquatic food web. Much concern is focused on methylmercury (MeHg) as it is the most bioavailable species. In this study, we are identifying factors causing high Hg methylation (transformation of inorganic Hg to MeHg) and mobilization both in space (i.e., hot-spots) and time (i.e., hot-moments). The mercury methylation rate has been suggested to increase when oxidized soils or sediments become reduced. The restoration of Lake Perez in a forested region of central Pennsylvania could thereby act as a potential methylation hot-spot. Soil/sediment as well as water samples are being collected before and after the lake has been filled to evaluate if the restoration causes increased methylation. High flow episodes are usually identified as hot-moments for Hg in forested catchments. Further, we are sampling a forested stream nearby during stormflow events to consider hot-moments, as well as factors influencing the mobilization of Hg in catchments, such as how organic matter characteristics are influencing the mobilization of Hg.

Effects of forestry on mercury runoff in catchment-scale studies in Sweden. Eklöf, K. (*Pennsylvania State University, USA; kje15@psu.edu*), Schelker, J., Sørensen, R., Åkerblom, S. (*Swedish University of Agricultural Sciences, Sweden; jakob.schelker@slu.se; rasmusvis@gmail.com; staffan.akerblom@slu.se*), Weyhenmeyer, G. (*Uppsala University, Sweden; gesa.weyhenmeyer@ebc.uu.se*), Kraus, A., Brömssen, C., Laudon, H., Boyer, E., Meili, M, Bishop, K.*; Kevin.Bishop@slu.se*).

Forestry operations have been found to increase the export of total mercury (THg) and methyl mercury (MeHg) to surface waters. However, little is known about the relative contribution of different forestry operations. In catchment-scale studies in Sweden, the individual effects of different forestry operations were evaluated. Stump harvesting, done to increase the amount of biofuels supplied from the forest, was compared with traditional site preparation for replanting. The stump harvest did not increase THg and MeHg concentrations in runoff relative to site preparation. However, the runoff concentrations were higher in both the stump harvested and site prepared catchments relative to the references. The relative importance of the logging itself, compared to the subsequent site preparation was investigated in catchments in northern Sweden. A more pronounced effect on the mercury concentrations after site preparation compared to logging only could be related to the site preparation being conducted during summer, causing more soil disturbance than the logging which was done during winter, with snow covering the ground. The results suggest that when and how forestry operations are implemented might be more important than the kind of treatment. These studies also identify a great variation in sensitivity to forestry operations between catchments.

Evapotranspiration (ET) as an ecosystem service: why we should care about precipitation recycling. Ellison, D., Futter, M., Bishop, K., Laudon, H. (*Swedish University of Agricultural Sciences (SLU), Sweden; ellisondl@gmail.com; Martyn.Futter@slu.se; Kevin.Bishop@slu.se; Hjalmar.Laudon@slu.se*).

Forests provide a number of important water-related ecosystem services including water purification and flood mitigation. Here we show that the precipitation-recycling role of forests must also be recognized as an ecosystem service. The role of forests as controllers of the hydrological cycle is clearly recognized. Deforestation leads to more local runoff and reduced precipitation. However, the importance of afforestation in promoting precipitation recycling is not sufficiently appreciated. Much of the evapotranspiration from forests falls as precipitation in downwind continental locations. Using hypothetical examples, we demonstrate the possible consequences of changes in precipitation recycling for both continental and local precipitation. Using

real data from a series of Swedish and at least one U.S. catchment, we illustrate the potential consequences of changes in forest cover on local and regional scales. Changing forest cover to modify the balance between runoff and evapotranspiration has hitherto unrecognized policy consequences. Here, we argue these consequences are not adequately recognized either in current legislation such as the Water Framework Directive, nor in the current discussions about payment for ecosystem services.

Establishment of hydrometeorological stations in national power corporation-managed reservations. Exconde, A., Daño, A., Atega, P., Castillo, J., Garcia, D. (*Ecosystems Research and Development Bureau (DENR), Philippines; angelitoexconde@yahoo.com.ph; tonydanolb@yahoo.com; pcatega@yahoo.com; alan536@yahoo.com; digsgarcia@yahoo.com*).

This study endeavors to establish hydrometeorological stations in National Power Corporation (NPC)-managed reservations to acquire hydrologic measurements, specifically rainfall, wind, and temperature, for hydrometeorologic monitoring. Collected data are important for hydrologic research since the climate and weather of an area profoundly influences most hydrologic processes. The NPC, the Philippines' largest energy producer in Mindanao, is dependent on hydrologic processes to produce energy, and thus needs reliable hydrometeorologic data to effectively plan and implement the integrated conservation and management practices needed to achieve sustained forest and other natural and agricultural resources. Mini hydrometeorological stations containing complete sets of calibrated automatic weather monitoring instruments and other manual instruments like 8-inch standard rain gauge, evaporation pan, and anemometer have been fabricated and installed in 11 major watersheds around the Philippines to measure and collect hydrometeorological data. The instruments were tested, and collected data were tested for correctness and accuracy. Skills enhancement training workshops in proper handling, collection, recording, and analysis of data have been conducted to train the station staff. The data for rainfall, wind, and temperature are then stored in the NPC Database System. This study can serve as a model for future studies on hydrology.

How green are forest fragments inserted into tropical agricultural landscapes? implications for ecosystem services provisioning. Ferraz, S., Ferraz, K., Cassiano, C. (*University of São Paulo, Brazil; silvio.ferraz@usp.br; katia.ferraz@usp.br; carla_cassiano@hotmail.com*).

Tropical forests play an important role regarding ecosystem services related to biodiversity, water, and nutrient cycling in such dynamic landscapes. Historical processes of deforestation culminate on native forest at different landscape structure and quality. We assessed historical land-use changes (1962–2008) at southeast region of Brazil using aerial photographs. Digitizing and parameters calculation were performed in ecological units based on historical forest polygon map overlays. Using LUCAT (Land-Use Change Analysis Tools), Forest dynamics were assessed by forest change curvature profile (FCCP) and forest change rate (Q). Landscape structure was assessed by neighborhood, proximity, and contiguity indices. Results showed that natural forests have increased from 8% to 16%, but besides that, transition matrix showed that old forests are being reduced while new areas are being regenerated. Historical analysis showed that current forest remnants are a result of different processes of spatial and temporal dispersed deforestation and regeneration. Different forest ages, forest dynamic processes, and current landscape structure together reveal a mosaic of forest patches under different conditions, implying a potential gradient of performance on ecosystem services what could not be represented by a single color fragment on a map, since only 25% of patches were considered able to fully perform ecosystem services.

Study of the tropical Sudanian area's major agroforestry landscape patterns involvement in carbon sequestration balance in Togo. Folega, F., Zhang, C. (*Beijing Forestry University, China; ffolega@yahoo.fr; zcy_0520@163.com*), Wala, K., Batawila, K. (*University of Lomé, Togo; kpwala75@yahoo.fr; batawilakomlan@yahoo.com*), Zhao, X. (*Beijing Forestry University; bfuz@163.com*), Akpagana, K. (*University of Lomé, Togo; koffi2100@gmail.com*).

This research was aimed at estimating total carbon stock in the tropical Sudanian zone agroforestry system of Togo. Physical measurements of trees (*Adansonia digitata, Parkia biglobosa, Sterculia setigera, Vitellaria paradoxa,* and fallows) in major agrosylviculture parklands were achieved by random quadrat sampling based on Braun-Blanquet concept. The total carbon stock was computed as the arithmetic mean of the values derived from two allometric equations. Results revealed that the total carbon stock of the agroforestry parkland was 72.8 t/ha whereas *A. digitata, P.biglobosa, S. setigera,* and *V. paradoxa* trees species accumulate 31.41 t/ha, 20.44 t/ha, 8.48 t/ha, and 4.02 t/ha, respectively. The *A. digitata* parkland has shown the highest total carbon stock (15.91±12.9 t/ha), whereas the lows values occurred in fallows landscapes (0.24±0.06 t/ha). Among the five parklands of the study zone, high carbon stock accumulated in the DBH classes ranging from 0–10 and 30–40. The agroforestry system landscape in the study is a carbon pool, as it has a significant capacity to uptake and stock carbon. To realize the agroforestry and wooded vegetation sector's potential in Togo, the carbon mitigation should be integrated within the Clean Development Mechanism (CDM) carbon trading system of the Kyoto Protocol.

Fluvial water quality and forest cover in southern Brazil. Fritzsons, E., Parron, L. (*EMBRAPA, Brazil; elenice.fritzsons@embrapa.br; lucilia.parron@embrapa.br*), Mantovani, L. (*Federal University of Paraná, Brazil; lem@ufpr.br*), Wrege, M. (*EMBRAPA, Brazil; marcos.wrege@embrapa.br*).

In natural environments, water quality depends on physical and biological factors such as climatic, geologic, pedologic, and vegetation. In addition to natural factors, the various human activities affect the aquatic environment and modify the water composition parameters. The present study was carried out at the Fervida a Karst watershed, which covers an area of 13 km^2 and is located over the Southern Brazilian Plateau in the State of Paraná, Brazil, 900 to 1 200 m over sea level. The natural vegetation corresponds to the original area of subtropical Araucaria forest (*Araucaria angustifolia*). Agricultural activity consists of small-holder crops of vegetables, mainly of horticulture, maize, and beans. The regional climate is Cfb. The aim of this study is to analyze the impact caused by land use to the river water quality, especially considering the pollution by nitrates, and verify the protection provided by the riparian forest to the fluvial water. A land use study will be done through the interpretation of aerial photographs and satellite images. Forest fragments in the landscape will be evaluated. Meanwhile, water samples will be collected at five controls zones of the basin. Preliminary investigations show that forested areas have better water quality than those that drain from agricultural areas.

Soil carbon storage in different species dominating the Sarawak Mangrove Forest, Malaysia. Gandaseca, S., Imam Aritanto, C., Haruna Ahmed, O., Muhamad Majid, N. (*Universiti Putra Malaysia, Malaysia; seca@upm.edu.my; chan2_himura@yahoo.com; osumanu@upm.edu.my; nik@upm.edu.my*).

Carbon storage in forest ecosystems involves inordinate components including plant biomass carbon and soil carbon. Sequestration of carbon along with other aggressive conservation efforts helps to reduce the increasing negative impact of global warming on the environment and mangroves of the coastal forest. Sequestration also plays a substantial role in global carbon cycling because a large stock of carbon is stored as well as the potential carbon sinks and sources to the atmosphere. Soil of Awat-Awat Mangrove Forest (AAWF) were collected in nine different plots dominated with different species using a peat auger at a depth of 0 to 50 cm. A total of 32 samples were collected. Soil carbon content of AAWF varied in each plot. The different dominate species resulted in different carbon content. In AAWF, the highest soil carbon content (6.24%) was found in soil under *Rhizophora mucronata*, whereas the lowest carbon content (1.73%) was in soil under areas dominated by *Sonneratia alba*. In addition, the soil carbon content in areas dominated by different species in AAWF varied.

Conservation of wildlife outside protected areas in community forests in Nepal. Ghimire, M., Lamsal, R. (*Ministry of Forests and Soil Consertation, Nepal; ghimire.madhu@gmail.com; ramplamsal@gmail.com*).

Protected areas are an essential means for conserving biodiversity, however, biodiversity friendly forest management outside protected areas has been given high priority in recent years. Based on primary and secondary information from communities and forest offices, this study reviews the community-based wildlife conservation in Barandabhar forest corridor of Chitawan, Nepal; examines the management priorities of community forests (CFs) and their compatibility for wildlife management; and assesses the institutional and legal arrangements of CFs for wildlife conservation including the performance of community-based anti-poaching movement and management of human wildlife conflict. The results indicate: (a) habitat destruction mainly by invasive alien species has caused wildlife to move from the National Park to corridor CFs, where they are found with higher density and safer with reduced poaching incidents; (b) community forest operational plan provides the institutional and legal base to communities for forest and wildlife management including community-based anti-poaching efforts; and (c) attempts are made to minimize the human wildlife conflict, however, the increased magnitude may pose serious limitations on community-based conservation. Therefore, it is recommended for an alternate model of CF implementation in the corridor area.

Long- and short-term hydrogeomorphic processes alters the spatial variability of soil carbon and nutrient accumulations in headwater catchments of Japan. Gomi, T. Hiraoka, M., Quynh Anh, P. (*Tokyo University of Agriculture and Technology, Japan; gomit@cc.tuat.ac.jp; hiraokam@cc.tuat.ac.jp; quynhanh.vfu@gmail.com*).

We investigated the spatial distribution of understory vegetation ground covers in two headwater catchments of watershed 3 (7.0 ha) and watershed 4 (4.6 ha) of Japan. Deer over-grazing for the last three decades affected the species and distribution of understory vegetation in the watersheds. Hillslope with bare soil in watershed 3 was 1.3 ha, whereas one in the watershed 4 was 0.7 ha. Most of the hillslopes with bare surface and/or litters were located adjacent to stream channels with slopes gradient more than 40°. Canopy openness and hillslope gradient were critical factors for controlling vegetation ground cover. Dominant understory vegetation was non-preference and torrent species by deer over-grazing. Soil organic carbon (SOC) and soil organic nitrogen were positively correlated with understory vegetation biomass and soil bulk density. The amount of SOC tended to increase with increases in ^{137}Cs and $^{210}Pb_{ex}$ which indicate long-term soil erosional processes. Our findings suggest that vegetation types and the resultant long- and short-term soil erosion processes may feed back into both the production and accumulation of SOC, but forest cover did not always result in high soil fertility or low erosion.

Long-term variation of coefficients of peak discharge in a small watershed, in association with forest restoration and succession on denuded hills. Gomyo, M. (*Forestry and Forest Products Research Institute, Japan; gomyo@affrc.go.jp*), KURAJI, K. (University of Tokyo*, Japan; kuraji_koichiro@uf.a.u-tokyo.ac.jp*).

The objective of this study was to quantify the changes in the coefficients of peak discharge (fp) with reference to the long-term natural recovery of forests on denuded hills. The Ananomiya Experimental Watershed at the Ecohydrology Research Institute (the University of Tokyo Forests) was selected for this study. We compared the relationship between fp and discharge when the discharge trend changed from decreasing to increasing (Qi) and from the onset of precipitation to the time when peak precipitation (Pi) was attained. This was done in order to estimate peak discharge during an early 11-year period and a late 22-year period. Regardless of whether measurements were taken during early or late periods, the fp increased when the Pi increased. Conversely, the relationship between fp and Qi, an indicator of the wetness condition of the watershed, was not clear. The maximum fp values during the late period, when Pi was 0, 25, and 50, represented a decrease of 53, 45, and 42%, respectively, with respect to the corresponding figures from the early period. This study showed that fp of a heavy precipitation event referred to as the Tokai Heavy Rain event (total precipitation of 401.5 mm), was 0.58, far below 1.0.

Vegetation greenness and nebulosity in Central Africa. Gond, V. (*CIRAD, France; valery.gond@cirad.fr*), Philippon, N., Camberlin, P. (*CNRS/Université de Bourgogne, France; Nathalie.Philippon@u-bourgogne.fr; Pierre.Camberlin@u-bourgogne.fr*), Cornu, G., Gourlet-Fleury, S. (*CIRAD, France; Guillaume.cornu@cirad.fr; sylvie.gourlet-fleury@cirad.fr*), de Lapparent, B. (*CNRS/Université de Bourgogne, France; benjamin-de-lapparent@hotmail.fr*).

In the next decades, central African forests are predicted to experience profound climatic changes with increased temperature, alteration of rainfall patterns, and possibly longer dry seasons. In this context it is important to understand the climate variables and mechanisms driving the forest photosynthetic activity. Relationships between central African forests canopy photosynthetic activity and climatic parameters have not been documented enough. We propose here to analyze the mean (seasonal cycle) and inter-annual (year to year variations) temporal dynamic of EVI (enhanced vegetation index) for a region comprised between 0–5°N and 13–19°E with respect to climatic parameters potentially influencing the vegetation such as rainfall and nebulosity (through light intensity). We evidenced using coarse resolution cloud cover data that the forest photosynthetic activity mean

seasonal cycle matches seasonal changes in the cloud cover. These changes affect both the cloud cover fraction and the cloud types. This is currently explored using the more adequate MSG (Meteosat Second Generation) data. These results are of crucial importance to support the hypothesis of a strong dependence of central Africa forests cover with climatic seasonal to inter-annual variations.

Biotic homogenization and differentiation of the flora within man-made and near-natural habitats across urban green spaces in Shenzhen, China. Gong, C., Ning, Z. (*Southern University, USA; chongfeng.gong@gmail.com; Zhu_ning@subr.edu*).

Shenzhen, a new city existing for less than three decades, experienced dramatic biological invasions of alien plants resulting from the development of urban green spaces. In an investigation of plant species from 390 plots in 186 sites across five main types of green spaces (forests, public parks, vegetation corridors, residential, and industrial area), a total of 474 plant species, including 221 alien species (46.6%), were recorded. Our study witnessed the spread and establishment of alien species across all urban green spaces, with greater proportions of alien species in the man-made ones than in the natural ones. Furthermore, we found the positive relationship between native and alien species richness existed across all the green spaces, and it was particularly prevalent in the man-made ones. Additionally, successful establishment of alien species instigated by anthropogenic disturbances and most frequent species assemblages caused biotic homogenization in the man-made ones. In contrast, biotic differentiation in the near-natural habitats was still preserved due to a greater level of protection for native species, resulting in resistance against the establishment of alien species. Therefore, urbanization was proven to have distinct effects on the biota of human-modified and near-natural habitats coexisting in the new city.

Adaptive water-oriented forest management using BIOME-BGC in Mediterranean Aleppo pine plantations. Gonzalez-Sanchis, M., Campo, A. (*Universitat Politecnica de Valencia, Spain; macgonsa@gmail.com; ancamga@dihma.upv.es*), Molina, A. (*Institute of Agrifood Research and Technology, Spain; amolihe@gmail.com*), Fernandes, T. (*Federal University of Acre, Brazil; tjgfernandes@yahoo.com.br*), García Prats, A. (*Universidad Politécnica de Valencia, Spain; agprats@upvnet.upv.es*).

Water-oriented Forest Management (WOFM) aims to adapt the forest to water availability by means of affecting forest structure and density. Regions under water scarcity situations, such as the Mediterranean, might require WOFM to optimize the hydrological cycle under normal and future global change conditions. The present study uses the process based model BIOME-BGC to predict the effects of WOFM in a Mediterranean Aleppo pine plantation. At the same time, the present work pretends to make easier the model application to forest managers. To that end, the model is slightly modified where canopy average specific leaf area and canopy water interception coefficient are both introduced as a function of forest coverage. Then, the model is calibrated and validated using a year sapflow, soil moisture, and throughfall field data from three forest covers (85 to 26%). Calibration and validation show an acceptable accuracy, whose Nash–Sutcliffe ranges between 0.39–0.76 and 0.31–69, respectively. The model is finally applied to analyze and predict the need of forest management in a Mediterranean forest. The application shows an optimization of the hydrological cycle that establishes a new equilibrium between blue and green water. The new scenario significantly reduces water interception and transpiration and increases runoff and percolation.

Assessing the trail condition and environmental factors of the Kumano pilgrimage routes in the Kii Mountains, Japan. Gou, S. (*Kyoto University, Japan; shiwei.gou@gmail.com*).

Kumano Kodo (officially referred as Kumano Sankeimichi) are pilgrimage routes traversing diverse landscapes of Kii mountain range and were inscribed collectively with other cultural properties as the UNESCO World Cultural Heritage Site, Sacred Sites and Pilgrimage Routes in the Kii Mountain Range in 2004. Bearing distinctive religious and cultural meaning, these routes are also popular hiking trails for both domestic and international tourists. Historically maintained by surrounding residents for their daily life and silvicultural practices as well as religious practices for people coming from all over the country, Kumano Kodo are facing serious deterioration nowadays due to a complex combination of environmental, cultural, and social factors associated with intensive plantation and lack of proper management of the planted forest in the surrounding area. This research used systematic sampling methods of 100 m interval along the trail from Takiji Oji to Kumano Hongu Taisha Shrine (about 30 km), one of the most popular sections of Kumano Kodo, to investigate the current condition of the Kumano Kodo, and the influences of a wide range of use-related, environmental, and managerial factors on the condition of the trail in order to purpose possible solutions tailored to deterioration of the pilgrimage routes under different situations.

Coarse woody debris characteristics: a case study in a 9-ha old-growth cold-temperate coniferous forest plot from Great Hing'an Mountains, Northeastern China. Gu, H. (*Northeast Forestry University, China; ghuiyan@nefu.edu.cn*).

Coarse woody debris (CWD) volume is a vital attribute of forest ecosystems and plays a key role in global C cycle. However, despite their importance, there have been no reports of CWD volume in China boreal forests. We carried out this study in the old-growth cold-temperate coniferous forest located in the "Huzhong" National Natural Forest Reserve in Great Hing'an Mountains in Heilongjiang Province. The forest covers an area of 1.7×10^5 ha in the reserve owned by the local government. In 2011, a large-scale plot (9 ha) was selected for an intensive study of stand structure and the quantity and quality of CWD. Our result showed: (1) the growing volume of living trees was 142.3 m^3/ha with the species *Larix gmelinii* accounting for more than 90% of the total living volume; (2) The average volume of CWD was 87.4 m^3/ha, and among the CWD, the volume of primary decay and intermediate decay (more than 60%) was greater than the volume of advanced decay (less than 30%); and (3) Of the total volume of dead and living trees, CWD comprised 61.4%. Considering these results, we concluded that the amount of carbon stored in the boreal forest is underestimation, as CWD comprise a significant fraction of the total volume in boreal forest.

Life cycle evaluation of forest sector greenhouse gas emissions sensitivity to changes in forest management in Maine (USA). Gunn, J. (*Spatial Informatics Group – Natural Assets Laboratory, USA; jgunn@sig-nal.org*), Hennigar, C. (*FORUS Research, Canada; FORUS.Research@gmail.com*), Cameron, R. (*University of New Brunswick, Canada; cameron.ryan.e@gmail.com*), Buchholz, T. (*University of Vermont & Spatial Informatics Group LLC, USA; tbuchholz@sig-gis.com*).

We used a life cycle greenhouse gas accounting tool to test sensitivity of Maine (USA) statewide forest sector greenhouse gas (GHG) emissions to changes in forest management using forest cover data and growth and yield models for the state of Maine.

We summarized net GHG emissions over 100 and 300 year time horizons of different management strategies across a range of carbon pools and emission sources. Carbon pools include: (1) storage in aboveground and belowground live and dead biomass; (2) storage in forest products in use and in landfills; (3) harvest, transport, and manufacturing emissions; 4) avoided emissions (substitution; bioenergy); and (5) landfill methane fluxes. The current baseline forest sector is a net GHG sink throughout the 300 year modeling period. Greater use of even-aged management increases total emissions compared to the baseline. When forest product substitution for fossil-fuel intensive building materials is considered, increasing uneven-aged silvicultural systems reduces forest sector GHG emissions compared to the baseline. Scenarios that increase area of protected reserves compare favorably with baseline GHG emissions predicted for reduced harvesting intensity scenarios when product substitution is not considered.

Restoring ecological legacies in boreal Sweden: a saproxylic beetles perspective. Hägglund, R., Hjälten, J. (*Swedish University of Agricultural Sciences, Sweden; ruaridh.hagglund@slu.se; joakim.hjalten@slu.se*), Dynesius, M. (*Umeå University, Sweden; mats.dynesius@emg.umu.se*), Roberge, J., Johansson, T., Olsson, J (*Swedish University of Agricultural Sciences (SLU), Sweden; Jean-Michel.Roberge@slu.se; therese.johansson@slu.se; jorgen.m.olsson@slu.se*).

Forest practices in boreal Sweden have during the last two centuries led to simplified forest structure and more homogeneous tree species composition, resulting in declining biodiversity in order to reduce the rate of decline restoration of ecological legacies already plays, and in the future will play an even more important role. In order to carry out restorations in an efficient manor, knowledge on the efficacy of different restoration measures is essential. By using a replicated design we have compared species composition of saproxylic beetle communities after two active restoration methods and compared these with both temporal and spatial controls. The two treatments carried out were prescribed forest fire and artificial gap cuttings. Both treatments have increased structural complexity and added substantial amounts of dead wood to the treated forest stands. Intercept traps of the IBL-model were used in the collection of beetles. Preliminary results suggest that changes in the species composition of saproxylic beetle communities has occurred in the treated stands compared to the base line and spatial controls. Especially noteworthy is the increase in pyrophylic species in the burned sites.

The assessment techniques of desert ecosystem services in China. Hao, G., Shi, Z., Xianghui, C. (*Chinese Academy of Forestry, China; guohaomail@163.com; shijie1204@163.com; cxh_lion@126.com*).

Desert ecosystem services are gradually becoming appreciated by the public as a greater awareness and understanding of the function of desert ecosystem is acquired. Compared to other ecosystem, the desert ecosystem has unique structure and function, but the services are very poorly known. So how these can be evaluates and how scientific, reasonable and feasible assessment index systems can be established become urgent problems in the present time. Considering thoroughly desert ecosystem service mechanisms, adopting frequency analysis and experts consultation methods, and index system and methodology for desert ecosystem service assessment in China has been established, along with the development of world's first desert ecosystem service assessment criteria (Assessment criteria of desert ecosystem services in China), be promulgated on Feb 23, 2012 by the State Forestry Administration of the PRC. These efforts will greatly promote the research and work of desert ecosystem services assessment in the world.

Bioenergy production and soil sustainability in the Pacific Northwest USA. Harrison, R. (*University of Washington, USA; robh@uw.edu*), Knight, E. (*Shannon & Wilson, USA; erika.j.knight@gmail.com*), James, J., Menegale, M., Michelsen-Correa, S., Turnblom, E., Eastin, I. (*University of Washington, USA; jajames@uw.edu; marcism@uw.edu; smiccor@gmail.com; ect@u.washington.edu; eastin@uw.edu*).

Though it has often been expressed in other terms, the basis of sustainability of bioenergy production in the Pacific Northwest is primarily soil-centered, dependent on the extent and availability of soil nutrient pools. Some PNW forest soils are very low in total and available nutrients relative to the current pools and inputs and would be sensitive to normal harvesting, whereas many soils are very rich in nutrients relative to intensive removals and are very resilient to high rates of biomass removal. Research at Fall River, Matlock, and Molalla long-term soil productivity projects show high resilience based on soil nutrient levels in the PNW, though other work in 72 forest plantation sites from northern Vancouver Island, Canada to southern Oregon show a wide range of soil nutrient pools, and potentially sensitive sites. Additional work on 22 forest plantations shows that many sites have substantial amounts of nutrients in deep soils (up to 3–4 m), and trees seem to be utilizing this soil zone. Some fire-driven systems would benefit from removal of biomass for bioenergy by reducing susceptibility to catastrophic wildfire. In nearly all cases, loss of nutrients through high rates of biomass removal can be substituted by adding removed nutrients; however, environmental and social considerations are typically the driving forces that limit expansion of biomass-to-energy growth in the region.

Model-based assessment of land-use / land-cover change on water quality and economic outcomes in an agricultural watershed in north central Portugal. Hawtree, D., Feger, K. (*Dresden University of Technology, Germany; dhawtree@gmail.com; fegerkh@forst.tu-dresden.de*), Pettenella, D. (*University of Padova, Italy; davide.pettenella@unipd.it*), Nunes, J., Roebeling, P., Abrantes, N. (*University of Aveiro, Portugal; jpcn@ua.pt; peter.roebeling@ua.pt; njabrantes@ua.pt*).

Efforts to improve water quality through alterations in land-use and/or land-cover (LULC) must be considered within a broader economic context, so the potential financial impacts on local stakeholders can be better understood and quantified. The Cértima watershed, located in north-central Portugal, is heavily utilized for agriculture and has persistent concerns related to low water quality. This threatens downstream aquatic environments (including the natural lake Pateira de Fermentelos and the Ria de Aveiro lagoon), as well as local groundwater supplies. This study utilizes an eco-hydrologic model, the Soil and Water Assessment Tool, to examine the water quality impacts of potential LULC changes, such as the implementation of agricultural best management practices and/or land conversion (including afforestation options). This output is then used to generate economic assessments of the cost-benefit of these different alternatives to provide a baseline of different land-use options. These results are considered within the context of Portugal's obligations under the Water Framework Directive, and the financial impacts of noncompliance as compared to the cost of implementing steps necessary for water quality improvements.

Potassium availability in smectitic soils under *Gmelina arborea* and *Pachira quinata* plantations of tropical dry forest in north Colombia. Henao Toro, M. (*Universidad Nacional de Colombia, Colombia; mchenaoto@unal.edu.co*), Escobar Quemba, L., Cadena Romero, M. (*Universidad Distrital Francisco José de Caldas, Colombia; hojyann@yahoo.com; mecadenar@udistrital.edu.co*).

In the Colombian north region, *Gmelina arborea* plantations grow in soils with high saturations of calcium and magnesium, which could reduce potassium uptake. The objective of this research was to evaluate potassium availability for these plantations through measurement of K fractions (soil solution, exchangeable, non-exchangeable, and structural), K selectivity (Gapon coefficients, K_G), K quantity-intensity relationships (Q/I), and K release capacity. Soils in the study area are Vertisols and Inceptisols. DRX data indicated that smectite is the predominant mineral in the clay fraction of both soil orders, followed by micas. K fractions and K release capacity were similar in two soil types, although Inceptisols presented lesser content in soil solution (1.3 mg/kg), exchangeable (335.2 mg/kg), non-exchangeable (31.0 mg/kg), and structural (6258 mg/kg). Non-exchangeable potassium was much lower in Inceptisols than Vertisols, showing a more limited buffering capacity for K from non-exchange to exchange sites, which could be related with lower clay content in Inceptisols. Both soils showed a higher selectivity for calcium than potassium, with low potassium K_G and Q/I (2.7 to 3.5 $(mol/l)^{-1/2}$ and 15.4 to 21.1 $cmol_c/kg\ (mol/l)^{1/2}$, respectively), even if high amounts of exchangeable and reserve K were found.

Invasive North American beaver (Castor canadensis) habitat selection and impact in Tierra del Fuego, Argentina. Henn, J. (*Centro Austral de Investigaciones Cientificas, Argentina; henn.jonathan@gmail.com*), Martinez Pastur, G. (*Consejo Nacional de Investigaciones Científicas y Técnicas* (CONICET), *Argentina; cadicforestal@gmail.com*), Anderson, C. (*Centro Austral de Investigaciones Cientificas, Argentina; canderson@alumni.unc.edu*).

Since their introduction in 1946, North American beavers (*Castor canadensis*) have spread through all of Tierra del Fuego, flooding and felling trees in riparian zones. As beaver populations have grown and spread, the governments of Argentina and Chile decided to eradicate beavers and restore degraded areas. However, little work has been done to understand beaver habitat selection and the areas that beavers could potentially occupy in the near future. The goal of this study was to fill this gap by surveying satellite images for beaver impact through the whole Argentine side of Tierra del Fuego. To do this, a grid of 175 points of approximately 200 ha each were surveyed for number of beaver ponds and area affected by beaver. Overall, there was an average of 1.7 beaver dams per 100 ha, and beaver engineering affected an estimated 1.4% of the total land area. Beaver effects were present more often than expected in forested areas ($X2=42.35$, $df=5$, $p<0.001$), especially in mixed forests (*Nothofagus pumilio* and *N. betuloides*). These data were used to build a habitat suitability model using ecological niche factor analysis that should be useful as planning for restoration and eradication efforts move forward.

Fungal succession after fire in *Cistus ladanifer* L. ecosystems. Hernandez Rodriguez, M., Martín-Pinto, P., Oria-de-Rueda, J. (*University of Valladolid, Spain; mariahr@pvs.uva.es; pmpinto@pvs.uva.es; oria@agro.uva.es*).

Wildfires are the major disturbance in Mediterranean ecosystems. After fire, fungal communities follow succession patterns mainly driven by the dynamics of post-fire plant communities. The aim of this study is to analyze post-fire fungal succession in a Mediterranean ecosystem dominated by *Cistus ladanifer* in northwestern Spain. Sporocarps were collected and identified on a weekly basis during the autumn season from 2003 to 2006 in 100 m^2 plots located in recently burned plots (early stage) and mature stands (late stage). A total of 146 fungal taxa were found during the 4-year sampling. There was a shift in the taxa composition of the fungal community during *C. ladanifer* succession. *Cistus*-specific taxa were classified as multi-stage taxa as they were able to fruit in both early and late stages. Furthermore, several mycorrhizal taxa, usually associated with mature forest tree stands, were able to fruit much earlier in *C. ladanifer* scrublands. According to the results of this study, these ecosystems, traditionally considered ecologically and economically unproductive, seem to exhibit significant levels of fungal richness and can play an important role in diversity conservation as well as acting as a bridge for mycorrhizal inoculum in the recovery of forest stands after fire.

Fungal production after fire in *Pinus pinaster* stands using classificatory models. Hernandez Rodriguez, M., Martín-Pinto, P., Oria-de-Rueda, J., Vásquez Gassibe, P (*University of Valladolid, Spain; mariahr@pvs.uva.es; pmpinto@pvs.uva.es); oria@agro.uva.es; vasquez@ecmingenieriaambiental.com*).

This study was aimed at describing post-fire mushroom production in a Mediterranean ecosystem dominated by *Pinus pinaster* in the northwest of Spain and assessing the results by classificatory models. During the autumn periods 2003–2006, sporocarps from 115 fungal taxa were collected in burned and unburned areas and grouped into the following categories: saprotrophic/mycorrhizal and edible/non-edible. After wildfires, a significant reduction in the number of fungal species and fruit body biomass production was observed. Based on this relevant information, the first simple classificatory model was provided. Nine alternative models based on classifications according to combinations of edibility and functional groups were fitted, and four fruiting body biomass production classes were defined as possible responses. Time after fire and climatic variables were significantly related to fruit body production. The best predictive results were obtained for edible and edible-mycorrhizal models, with a correct classification rate of production classes of 92–85%. Moreover, obtained models were applied to analyze the effect of time after fire on fungal production. Mycorrhizal and edible fungal production after fire was classified into the lowest class, whereas saprotrophic and non-edible species followed a contrary trend. The classificatory models can be useful to optimize management and harvest of this appreciated forest resource.

Dendrometric indicators of understory vegetation along ecological gradients: do nonlinear models outperform linear ones? Herpigny, B., Gosselin, F., Vallet, P. (*National Research Institute of Science and Technology for Environment and Agriculture, France; basile.herpigny@irstea.fr; frederic.gosselin@irstea.fr; patrick.vallet@irstea.fr*).

Trees are among the main components of forest ecosystems. They affect understory vegetation composition and diversity through their influence on resources (light, water, nutrients). Therefore dendrometric indicators such as tree cover, species richness, or basal area are used as biodiversity indicators. Their effect varies along ecological gradients and among species. The relationship

between dendrometric indicators and understory plant diversity has already been modelled in some French plain forests. We extend the models to larger areas and take into account the variation of the relationship along ecological gradients. Those models are incorporated in the SIMMEM software, a forest simulator. We compare the efficiency of linear (general linear models) and nonlinear (such as models including asymptotes or threshold effect) forms when modelling the relationship between dendrometric indicators and understory plant species richness or abundance. We model this relationship at plot but also at landscape scale, including variables such as forest cover, hardwood or conifer percentage, and tree species abundance. Besides the sheer ecological interest, these models can also be included in the SIMMEM software, which can simulate the evolution of either forest plots or landscapes.

Biodiversity conservation on private lands: a comparative study of the USA and Europe. Hily, E., Stenger, A. (*National Institute for Agricultural Research* (*INRA), France; emeline.hily@gmail.com; anne.stenger@nancy.inra.fr*), Zhang, D. (*Auburn University, USA; ZHANGD1@auburn.edu*).

The objective of this paper is to review and compare the emergence and evolution of regulatory and market instruments for biodiversity conservation on private lands in the United States and Europe. We focus on the integration of these instruments (e.g., integration *via* environmental impact assessment, combination with economic instruments) and on the share of biodiversity conservation benefits and costs. Traditional conception of forestry has strongly influenced early definitions of regulatory tools for biodiversity conservation both in Europe and the United States. However, even though private forest owners in the United States nowadays have to comply with strong regulations such as the Endangered Species Act, new regulatory and market initiatives have provided them with added flexibility and incentives. Much of these new initiatives are developed in the U.S. because of this restrictive aspect of biodiversity conservation and strong reactions from private forest owners. On the one hand, a clear recognition of multifunctional forestry, the conception of private forest owners as biodiversity producers, and perhaps the lessons learned from the U.S. experience have oriented biodiversity conservation in Europe towards cooperation, voluntary approaches, and a hardly stringent regulation. We compare various regulations, incentive payments, and conservation market mechanisms and summarize their impacts in the United States and major countries in West Europe.

Mitigating effects on runoff chemistry after final felling using forest buffers. Högbom, L., Ring, E. (*Forestry Research Institute of Sweden, Sweden; lars.hogbom@skogforsk.se; eva.ring@skogforsk.se*), Löfgren, S. (*Swedish University of Agricultural Sciences, Sweden; stefan.lofgren@slu.se*).

Final felling typically affects water quality, in headwater streams in particular. In order to reduce negative effects, forest buffers left along the streams can be an efficient countermeasure. We have studied the effects of a narrow forest buffer along a small headwater stream in a paired-catchment study in Northern Sweden. The experimental site is situated in an area with low nitrogen deposition (2–3 kg N/ha/year). The study was initiated in 2004 and included in total six catchments; two catchments to be felled with or without leaving a forest buffer and two unfelled control catchments, and in addition, two larger catchments to investigate the effects on landscape scale. After two years of reference measurements two of the catchments were harvest, and in 2008 site preparation occurred. Water flow has been monitored using V-notch weirs. Runoff chemistry (c. 20 constituents) has been measured on a fortnight schedule for the last 8 years. In the stream surrounded by a forest buffer, the concentration of nitrate and ammonium in the runoff was substantially reduced as compared to the catchment without the buffer, while constituents like potassium, chloride, and total phosphorus increased regardless of the presence of a forest buffer.

Life cycle carbon and economic assessment of biochar-based bioenergy production in Ontario, Canada. Homagain, K., Shahi, C. (*Lakehead University NRM, Canada; khomagai@lakeheadu.ca; cshahi@lakeheadu.ca*).

Bioenergy is considered a carbon-neutral solution for the current environmental crisis. Biochar is a by-product of bioenergy which can sequester carbon for a longer time if applied in soil which is claimed to be carbon negative in the life-cycle. Fossil fuel related emissions are often blamed as one of the biggest contributors of current environmental greenhouse gas and subsequent global warming. Fossil fuels make up a significant proportion of the current power supply mix in Ontario. In order to reduce GHG emissions from coal fired power stations, the province of Ontario is phasing out coal firing plants and replacing with forest biomass plants by 2014. The use of biomass feedstock for power generation not only has the potential to address the environmental problems related to air pollution and climate change, but also ensures energy security for local communities. Production of biochar-based bioenergy by using woody biomass and replacing fossil fuel based power supply will have a very important impact in the environment. We conducted a thorough life cycle assessment using SimaPro® and EIO-LCA. Here we present a detailed life cycle carbon and economic assessment of biochar-based bioenergy production in Ontario, Canada with comparisons to conventional bioenergy production along with GHG and other environmental consequences.

Water erosion vulnerability of upland watersheds under different forest covers in the Chittagong Hill Tracts, Bangladesh. Hossain, M. (*University of Freiburg, Germany; mohitulh@yahoo.com*), Haque, S. (*University of Chittagong, Bangladesh; sms_haque@yahoo.com*), Olarieta, J. (*Universitat de Lleida, Spain; jramon.olarieta@macs.udl.cat*), Hossain, M. (*University of Chittagong, Bangladesh; noorhossain28@gmail.com*).

Water erosion is the most serious environmental problem in hilly watersheds of Bangladesh and is a major concern for forestry and agricultural productivity. It is, therefore, necessary to identify land use practices that will control this problem in order to establish sustainable watershed management strategies. In this context, the study was carried out in 21 different sites in the Chittagong Hill Tracts (CHTs) by conducting direct field assessments of soil loss under various land uses using erosion pins and pedestals measurement during the period 2009–2010. The results showed that average soil loss was highest (64 t/ha/yr) in deeply-tilled agricultural slopes, followed by *Tectona grandis* plantations (47 t/ha/yr), while the lowest soil losses (13 t /ha/yr) were recorded in bamboo plantations. Among the other forest plantations studied, soil loss rates were comparatively smaller under mixed-plantations (17 t/ha/yr) and *Gmelina arborea* plantations (30 t/ha/ya). Land use was the most significant factor explaining these erosion rates compared to slope and soil characteristics. This study can be useful to identify areas with high erosion risk and to develop adequate soil conservation measures in the hilly watershed of the CHTs.

Biomass and carbon stores estimated in 2011 and 1934 at Priest River Experimental Forest, northern Idaho, USA. Hudak, A., Sandquist, J., Jain, T., Byrne, J. (*U.S. Forest Service, USA; ahudak@fs.fed.us; jsandquist@fs.fed.us; tjain@fs.fed.us; jbyrne@fs.fed.us*), Fekety, P. (*University of Minnesota, USA; pafekety@gmail.com*), Falkowski, M, Wei, L., Marshall, J., Link, T., Kavanagh, K.

Environmental monitoring data have been collected at the ~3 000 ha Priest River Experimental Forest (PREF) in northern Idaho since 1911. Streamflow has doubled in the past 70 years while annual precipitation has remained unchanged. We hypothesize that these trends are due to forest succession. PREF was initially dominated by western white pine but today is dominated by western red-cedar; transpiration rates of western red-cedar are less than half those of western white pine. We estimated the effect of succession on forest biomass carbon by relating forest inventory data collected in 2011 to a 1934 stand map of timber type and age class. We impute 20 m × 20 m gridded maps of species-level forest biomass, measured in 2011 at 60 systematic forest inventory plots data, using as predictor variables canopy metrics derived from a 2011 airborne LiDAR collection. Mapped predictions are aggregated to the 1934 stand map polygons, and the timber type and age class attributes from the 1934 stand map are cross-walked to species-level biomass estimates using look-up tables with long-term data from permanent plots monitored at PREF since 1914. Results will inform landscape-level models of forest carbon and water budgets constrained by 1911–2011 climate records.

Debarking of trees by deer is affected by deer density, tree size, species palatability, and maximum snow depth. Iijima, H., Nagaike, T. (*Yamanashi Forest Research Institute, Japan; hayato.iijima@gmail.com; nagaike-zty@pref.yamanashi.lg.jp*).

The increase of deer density and the deer impacts on forest ecosystems are serious problems all over the world. Debarking, one of the impacts of deer, is frequently surveyed as the indicator of deer impacts, but the occurrence of debarking is known to fluctuate among studies. In this study, we examined factors for the variability of debarking in Yamanashi Prefecture, central Japan. Deer densities of spatially fine scale (ca. 5 × 5 km) were estimated with a Bayesian state-space model. We measured the presence of debarking of trees (> 3 cm in diameter at breast height) at 569 forests in Yamanashi Prefecture (n = 14 225). The occurrence of debarking was affected by deer density, tree size, species palatability, and maximum snow depth, but not the amount of understory vegetation.

Landscape of vulnerability: forest cover change and fragmentation in Istanbul, Turkey. İnan, M. (*Istanbul University, Turkey; inan@istanbul.edu.tr*), Inan, Z. (*Yeditepe University, Turkey; zerrinan@gmail.com*), Serengil, Y. (*Istanbul University, Turkey; serengil@istanbul.edu.tr*).

Because of its unique location between Asia and Europe, İstanbul is suffering from significantly increasing consumption rates and population growth that have caused great changes in land use, land cover, and new land use types which are not harmonious with the environment and forest areas of the city. The city scale landscape and forest areas are significantly impacted by human-environment interaction in Istanbul, and consequently, rapid change in forest habitats have occurred. In this study, a GIS based system is executed and presented to identify the land use changes and evaluate the forest change and forest cover fragmentation by using Landsat images between the years of 1987, 2006, and 2013. Changes in landscape patterns, habitat fragmentation, habitat quality, and forest corridor alternatives between these fragmented habitats are analyzed by the system. Based on these analyses, some recommendations are discussed for forest landscape planning and management for sustainability of forest habitats and wildlife.

Forest adaptation to climate change in Iran. Jafari, M. (*Research Institute of Forests and Rangelands, Iran; mostafajafari@libero.it*).

Mitigation and adaptation are two main strategies to address climate change (CC). Various stakeholders define and interpret adaptation quite differently. Multiple dimensions of the adaptation process, programs, policies, strategies, and actions have three steps: (1) assess risks, (2) implement adaptation, and (3) review effectiveness. The adaptation capacities that have the potential to reduce adverse impact of CC and should be considered include increasing the sink for emissions and reducing the source of gases. Increasing the capacities of sink potentials could be implemented in two ways and include an increase in area and increase of volume potential. Decreasing the emissions sources capacities could be accomplished by a decrease in areas and decrease of volume potential. Urban forestry might be considered as an opportunity responding to the CC. The CE of LFCCs situated in Tehran could be used as a tool for urban and pre-urban forestry at local, national, regional, and international levels. Hyrcanian and Zagrosian forest ecosystems have tolerated the CC in the past centuries based upon the ability of the species. Fragmented and degraded forests will be unable to adapt to rapidly changing conditions. An overview of the major categories of changes expected in forest ecosystems as a consequence of CC include disturbance, simplification, movement, age reduction, and extinction or extirpation.

Relationships between vegetation, tree canopy composition, and soil in canopy gaps in dry *Pinus sylvestris* stands. Jankovska, I., Brumelis, G., Straupmanis, G., Amatniece, V., Dauskane, I. (*University of Latvia, Latvia; ilze.jankovska@llu.lv; guntis.brumelis@lu.lv; gustavs.straupmanis@inbox.lv; vita-amatniece@inbox.lv; iluta.dauskane@lu.lv*).

The aim of this study was to determine the effects of changes in tree species composition and soils on vegetation in canopy gaps of dry *Pinus sylvestris* forest stands. The study was conducted in forest stands located in the outskirts of the City of Riga in Latvia. Recreation and pollution loads in the city are leading to conversion of nutrient poor coniferous tree ecosystems to deciduous tree cover. Conversion of the 15 canopy gaps of various sizes were measured. In the gaps, vegetation was described and tree saplings and shrubs were counted and measured. For data analysis, the vegetation was described using plant traits. Tree discs and cores were removed for estimation of sapling age. Soil samples were collected at three depths for determination of pH, organic content, and N, P, and base cation concentrations. Gradual invasion of deciduous tree species in canopy gaps was associated with soil changes and increased shade. Both of these factors are causing a loss of the typical moss-dominated plant communities and an increase in cover of graminoid and forb species.

Evaluating vegetation complexity at different site conditions of subtropical forest of Okinawa Island Japan. Jemali, N. (*Kagoshima University, Japan; idiana0303@yahoo.com*), Shiba, M. (*University of the Ryukyus, Japan; mshiba@agr.u-ryukyu.ac.jp*), Binti Ahmad Zawawi, A. (*Kagoshima University, Japan; azitazawawi@gmail.com*).

The purpose of this paper was to study vertical vegetation structure and spatial distribution of several subtropical broadleaved trees species in Okinawa Island, Japan. Data was collected from Okinawa prefectural forest in 2012 and 2013 with different site condition. Forest monitoring resource survey under National Forest Inventory System method was utilized to provide objective data for forestry planning as well as to understand the biodiversity and productivity of forest ecosystem and carbon cycle. Plots were established in a concentric fashion with three different circle sizes. The radii of small, medium, and large circles were 5.64 m, 11.28 m, and 17.84 m respectively. In each plot, investigation of general plot condition was recorded including aspect, slope, soil type, distance from road and villages, complete tree tally on DBH (>1 cm), tree height, species name, tree health condition, and number of adjacent seedlings. The analysis was carried out from statistical and spatial analysis including species richness, Shannon's and Simpson's diversity indexes, and degree of concentration on each species. Methods for evaluating forest structure in a complex topographical condition at the studied forest are also discussed in this paper.

Quantifying carbon reduction services by urban landscape trees in Korea. Jo, H., Kim, J., Park, H. (*Kangwon National University, Republic of Korea; jhk@kangwon.ac.kr; kjy84@kangwon.ac.kr; bhm63@kangwon.ac.kr*).

The purpose of this study was to quantify storage and annual uptake of atmospheric carbon by urban landscape trees through a direct harvesting method. The study selected eight tree species that are popular for urban landscape plantings in Korea: *Abies holophylla*, *Acer palmatum*, *Ginkgo biloba*, *Pinus densiflora*, *Pinus koraiensis*, *Prunus yedoensis*, *Taxus cuspidata*, and *Zelkova serrata*. Ten to eleven individuals of each species, for a total of 82 trees, were sampled reflecting various diameter sizes at a given interval. The study measured biomass for each part including the roots of sample trees to compute total carbon storage per tree. Annual carbon uptake per tree was also quantified by analyzing radial growth rates of stem samples at breast height or ground level. Carbon reduction services by an urban tree were greater than those by a forest tree for the same species and diameter sizes. The study has broken new ground to overcome limitations of carbon estimation for urban landscape trees associated with a difficulty in direct cutting and root digging. [This work was supported by the National Research Foundation of Korea (NRF) Grant funded by the Korean Government (MOE) (2011-0009379)].

Epiphytes on *Pinus mugo* introduced around 1850 from the Alps to Danish coastal dune systems. Johnsen, I. (*University of Copenhagen, Denmark; ibj@bio.ku.dk*).

Pinus mugo (Mountain Pine) is native to the high alpine region of southern Europe. It was introduced to the west coast of Jutland, Denmark during the 1850s and was planted on the Skagen Spit to reduce sand drift. The study presented in this paper refers to Skagen Plantation, just south of the city of Skagen, the northernmost city of Jutland. These plantations are now mainly of historic value, as the sand drift is being controlled otherwise or accepted as a natural phenomenon. Similarities and differences between the epiphytic vegetation of lichens and bryophytes of the Danish *Pinus mugo* stands compared with alpine stands of the same species are being presented and discussed. The genus *Ochrolechia* is subject to particular scrutiny, as there apparently is only one common species (*Ochrolechia microstictoides)* among the epiphytes on *Pinus mugo* in the Alps and Denmark. It is also discussed whether the present day high Danish levels of atmospheric deposition of nitrogen and phosphorus compounds may be reflected in the epiphytic vegetation of *Pinus mugo*. Included in the paper is also a presentation of the ground vegetation below the *Pinus mugo* stands. The terrestrial vegetation of lichens and bryophytes within the *Pinus mugo* stands is briefly compared with the epigeic vegetation adjacent to the *Pinus mugo* plantations.

Spiders as indicators to evaluate the changes of a *Pinus taeda* plantation in grassland biodiversity in Uruguay. Jorge, C., Laborda, Á., Simó, M. (*Universidad de la Republica, Uruguay; carolina.jorge@cut.edu.uy; alaborda@fcien.edu.uy; simo@fcien.edu.uy*).

The objective of this study was to establish a suitable methodology for finding bioindicators of change that generate arthropod biodiversity in forest crops. Spiders are a megadiverse group and have proven to be good indicators of antropic ecosystem changes. Seasonal samples were taken from April 2011 to February 2012 in a *Pinus taeda* plantation in the northeast of Uruguay. For the relocation of the spiders we used two direct methods: nocturnal hand collection and a G-Vac. A total of 5 017 exemplars distributed in 21 families and 121 morphospecies were collected. Jacknife 1 estimator indicated that 70% of the araneofauna was sampled. Significant differences in the composition of species, families, guilds, and associations between both sites were recognized. The natural field was the site with the largest number of individuals, families, and species richness. Our results indicate that the culture of *P. taeda* generates changes in the composition and structure of the soil araneofauna regarding the natural field. The identification of indicator species for both study sites generates a knowledge framework for possible implementation in future monitoring in the context of sustainability and environmental certification in our country.

Flood generating areas: How much is land use/cover responsible? Kalin, L., Noori, N. (*Auburn University, USA; latif@auburn.edu; nzn0004@auburn.edu*).

This paper presents results from a study conducted in southeast coastal Alabama where we worked with two relatively small cities to identify critical areas within the 8-Mile Creek watershed that may have a higher contribution to downstream flooding, if developed. The watershed transitions from forested to urban land. It was shown that areas intuitively thought to have the highest impact on the increased high- or low-flows may not be critical at all. Highly impervious areas near the outlet of a watershed could contribute too quickly to the flow hydrograph such that their impact may only appear at the raising stage of the flow hydrograph. In other words, by the time peak flow is observed, flow generated from those areas might have already left the watershed. The interaction of different land use/cover at different parts of the watershed, flow travel times from those areas (mainly affected by topography and surface roughness), and soil types are important driving factors in the formation of the hydrographs. Results of this study led the two cities to work on modifications of their stream buffer ordinances. This study

showed that the inevitable population growth and economic development issues need to be holistically and sensibly addressed by government officials, planners, academia, developers, land owners, and others in ways that are environmentally protective and economically prudent.

Development of capacity building program in Thailand and Myanmar for combating desertification, land degradation, and drought. Kang, H. (*Seoul National University, Republic of Korea; silvi@chol.com*), Bang, M. (*University for Peace, Costa Rica; bangmiin@gmail.com*), Lee, P., Park, J. (*Seoul National University, Republic of Korea; shsnu337@gmail.com; parkjeongho82@gmail.com*), Kang, H. (*Dongguk University, Republic of Korea; hdk0225@dongguk.edu*).

Center for Combating Desertification in Arid and Semi-arid Areas (CCDASA, Korea Forest Service) is dealing with desertification, land degradation, and drought (DLDD) in Asia and Africa. The objective of our study is to develop a capacity building program for strengthening the capability of graduate students in conducting research on DLDD. In 2013, we organized two short-term training courses in Thailand and Myanmar. The course details include discussing DLDD issues in the workshop in Thailand, studying the current status of DLDD at the central dry zone of Myanmar, and exploring research topics on how to resolve DLDD in this region. Particularly, we developed these programs focusing on discussing DLDD with various stakeholders—international organizations, governmental agencies, research institutes, and local communities—in addition to field excursions. This provided the graduate students with the opportunity for learning how to consult local conditions most suitably to manage DLDD more effectively. We suggest further studies on sustainable land management at the central dry zone of Myanmar that could include improving soil quality, managing and developing water resources, and monitoring land use changes using geospatial techniques. (This study was carried out with the support of Forest Science & Technology Projects (Project No. S211212L030420) provided by Korea Forest Service.)

Collaborative research to combat desertification in arid and semi-arid areas. Kang, H. (*Dongguk University, Republic of Korea; hdk0225@dongguk.edu*), Woo, S. (*University of Seoul, Republic of Korea; wsy@uos.ac.kr*), Son, Y. (*Korea University, Republic of Korea; yson@korea.ac.kr*), Lee, S., Cho, W. (*Dongguk University, Republic of Korea; nash7700@hanmail.net; valkyre@naver.com*).

Some hybrids or clones grow well in desert areas because they have characteristics making them tolerant to drought, wind, sand, cold, heat, and salt. Improvement of popular species through the establishment of plantations is important to prevent desertification expansion in arid areas of Northeast Asia. We selected clones from the fast growing species that show strong tolerance traits to salt and cold, which have been developed through cross breeding and breeding by selection over the past ten decades from native and exotic local regions. The Center for Combating Desertification in Arid and Semi-arid Areas (CCDASA) was founded in 2012. It has been supported by the Korea Forest Service. The objectives of the center are to study scientific and technological desertification matters in arid and semi-arid areas, to make capacity building for graduate students in international society, and to learn relevant ways and means of how to combat desertification. The center also aims to establish networks in the country and to assist specialists in combating desertification through the country's training program and implementation based on UNCCD COP-10's follow-up action in Korea. The center is operating scientific and educational programs with the bilateral collaboration of other countries.

Tree census and diversity issues of urban forest of Chandigarh India: an update. Kohli, R. (*DAV University, India; rkkohli45@yahoo.com*), Jassal, J., Singh, N. (*Panjab University, India; jaswinder.j@hotmail.com; narayan.singh@gmail.com*).

For the present day environmental concerns and urban heat islands, trees are needed more in cities than anywhere else. The managers of urban communities find it really hard to grow and nurture the trees, especially in populated cities. Chandigarh in North India is one such city with population density exceeding 12 000 per square Km. In spite of several perceptible problems of spaces for trees and other related services, the city is wonderfully managing the urban forest character. With new inputs and ground truthing data on census and various related ecological indices, the objective of this presentation is to share the problems and the solutions thereof for a better upkeep of urban forests in crowded communities.

Sustainable wetlands adaptation and mitigation program (SWAMP). Kolka, R., Mackie, C. (*U.S. Forest Service, USA; rkolka@fs.fed.us; cmackie@fs.fed.us*), Murdiyarso, D. (*Center for International Forestry Research, Indonesia; d.murdiyarso@cgiar.org*), Kauffman, B. (*Oregon State University, USA; Boone.Kauffman@oregonstate.edu*), Anderson, C. (*U.S. Forest Service, USA; christamanderson@fs.fed.us*).

Carbon-rich tropical wetlands (mangroves and peatlands) are important in climate change adaptation and mitigation strategies and provide numerous ecosystem services such as storm protection, nursery areas for fish, habitat for rare species, long-term storage of carbon, and food, fiber, and fuel for humans. Because of their importance we developed the Sustainable Wetlands Adaptation and Mitigation Program (SWAMP) to assist countries with their accounting and conservation of tropical wetlands. SWAMP is a collaborative effort between the Center for International Forestry Research, U.S. Forest Service, and Oregon State University through support from the U.S. Agency for International Development. The goal of SWAMP is to provide policy makers and natural resource professionals with credible information and training to make sound decisions regarding the role of tropical wetlands in climate change adaptation and mitigation. The SWAMP objectives are to: (1) quantify greenhouse gas emissions from intact and disturbed wetlands; (2) quantify carbon stocks of representative tropical wetlands; (3) develop carbon modeling tools and scaling approaches using remote sensing; (4) define roles for tropical wetlands in climate change adaptation strategies; and (5) promote capacity building and outreach as integral parts of all activities. Here we discuss the accomplishments of SWAMP, current activities, and the future.

Adapting forest ecosystems in Kailash Sacred Landscape of Hindu Kush Himalayas for sustained flow of ecosystem services. Kotru, R. (*International Centre for Integrated Mountain Development (ICIMOD), Nepal; rkotru@icimod.org*).

The Kailash Sacred Landscape is a transboundary region consisting portion of the Tibetan Autonomous Region of China, and adjacent areas of India and Nepal, spread over 31 000 km^2. With a forest area of 36% this landscape is unique for being

culturally rich and ecologically diverse. Forest cover and its interface with other ecosystems provide inestimable transboundary ecosystem goods and services vitally important for lives and livelihoods of millions of people. Assessment of existing forest management systems show that burgeoning basic human needs of food, water and energy are not matched by sustainable forest management practices. Forests have been degraded as a result of over-harvesting, forest fires, heavy ungulate browsing or livestock grazing. Regional climate models combined with community science findings show that forests will be affected by climate change in future. The reactive and exclusionary forest protection policies, and enormous deficits in relevant information, innovative practices, stewardship and funding essential for judicious management to secure and sustain the host of environmental services whilst forest ecosystems adapt to climate change are a major constraint. The research suggests proactive forest management as the key to transform current stagnant forest sector to more adaptive and vibrant one for positive conservation and development outcomes.

Site conditions of Grey mangrove (Avicennia Marina) at Nayband National Marine Park. Kouhgardi, E., Akbarzadeh, M. (*Islamic Azad University, Iran; kouhgardi@yahoo.com; mehrdad.ak@gmail.com*).

In order to determine the relation among physiochemical parameters of water and soil as well as heavy metals of sediments and vegetative characteristics, samples of water and sediments were collected at the fifteen stations, with three repetitions in Nayband Mangrove Forest south of Iran. The results revealed that vegetation in most zones enjoys desirable conditions in view of qualitative parameters, and physiological weakness has only been observed at stations 6 and 7. Relying on results obtained, positive correlations only existed between average diameter and pH of water. Also, there was a negative significant correlation between pH of water and qualitative characteristics of trees ($P<0.05$). There was no significant correlation between amount of mercury and chrome and stand quality. Amount of nickel had a negative significant correlation with average height and average diameter of trees as well as vanadium and lead with all characteristics of Grey Mangrove ($p<0.05$). On a whole, quantity of lime on sediments, pH of water, completeness of tide, and quantity of vanadium and lead has an effective role on growth and quality of the stand that is a unique habitat for aquatic animals and landscape planning as well as coastal protection.

The species diversity of the steppes and the Sahara desert: central and southern Tunisia. Kwak, M., Woo, S. (*University of Seoul, Republic of Korea; 016na8349@hanmail.net; wsy@uos.ac.kr*), Khaldi, A., El Khorchani, A., Stiti, B. (*National Research Institute Of Rural Engineering, Water And Forests* (INRGREF), *Tunisia; khalditn@yahoo.fr; ali_el_khorchani@yahoo.fr; stiti_b@yahoo.fr*), Je, S., Lee, E., Yu, H., Jin, H., Kwon, Y.

One of the major environmental problems throughout Northern Africa is desertification of arid lands, specifically in Southern Tunisia (i.e., the semi-desert region of the northern Sahel Zone and the desertification of the northern margin of the Sahara Desert, in which desertification has occurred during the past few decades). Tunisia represents three different climatic zones forming a broad zone composed of a mixture of varied topography. Around 40% of the country is composed of the Sahara desert. Because of the geographic location, the northern part of Tunisia is influenced by the Mediterranean Sea climate. Sahara in southern Tunisia is desert due to the limited rainfall. Interestingly, central Tunisia is influenced by the combination of both. The vegetation of the steppes of central Tunisia and the Sahara desert of southern Tunisia is strongly dominated by chamaephytes (dwarf-shrubs) and therophytes (annual plants) such as *Acacia tortilis*, *Stipa tenacissima, Zygophyllum album, Artemisia campestris*, *Plantago albicans*, *Lygeum spartum*, *Artemisia herba-alba*, *Polygonum equisetiforme*, *Ruta chalepensis*, *Thymelaea hirsuta*, *Retama retam*, *Deverra scoparia*, *Scilla villosa*, *Anacyclus monanthos*, *Echium pycnanthum*, *Oudneya africana*, *Paronychia arabica*, *Euphorbia guyoniana*, *Astragalus armatus*, *Astragalus gombo*, *Aristida pungens*, *Lygeum spartum*, and *Rhus tripartita.*

Influence of forest management strategies and environmental conditions on epigeic arthropod biodiversity. La Rocca, C., Spence, J., He, F. (*University of Alberta, Canada; larocca@ualberta.ca; jspence@ualberta.ca; fhe@ualberta.ca*).

The relationship between biodiversity and ecosystem productivity is of great interest to foresters. Previous studies demonstrated a positive correlation between the increase of overall stored carbon in the system and biodiversity, a fundamental component for the assessment of better forest management strategies. However, evidence shows that this relationship is strongly influenced by environmental characteristics (temperature, moisture, ground cover,) more than from single Carbon indicators (DBH, coarse wood material). To test this hypothesis, we will use pitfall traps to collect epigeic arthropods (ground and rove beetles, spiders) and a series of environmental variables (DBH, coarse woody debris volume, ground cover, temperature, canopy cover, time since last disturbance) from sites in the boreal transition zone of central Alberta (Canada), selected on the basis of their age (time after harvesting) and retention strategies applied (percentage of trees retained during harvesting).Using ordination analyses and geo-statistical approaches, the goal of this study is to determine which factor has greater influence on species richness and relative abundance of litter and soil arthropods, to assess which forest management strategy (i.e., different retention level or time after the harvesting) is preferred.

Forest succession stagnation in southern Brazil forests – the role of bamboos. Lacerda, A., (EMBRAPA*, Brazil; andre.biscaia@embrapa.br),* Kellermann, B. (*Brazilian National Council for Scientific and Technological Development (CNPq), Brazil; kdbetina@hotmail.com*).

In this paper, we explore the relationship between bamboos and forest stagnation. After the 30-year die-off cycle of bamboo, other species begin to establish but are quickly overcome by bamboos as they recreate pure stands. In this context, long-term forest monitoring allows us to explore the role of bamboo in forest dynamics. As such, we monitored in EMBRAPA's Caçador Research Station (Santa Catarina, Brazil) 2 208 trees in 20 plots (15 m × 15 m) from two forest subtypes in 2007, 2010, and 2012: *Pristine* (few bamboos) and *bamboo* (dense bamboo populations, mainly *Merostachys skvortzovii*). The diversity of pristine forests fluctuates at around 60 species, whereas bamboo forests show three times fewer species and fewer individuals, with a slight declining trend. On the other hand, dominance (m^3/ha) in Pristine forests is increasing (82 to 87) but has stagnated at much lower levels (16) in bamboo forests. The results confirm that after bamboo die-off, a large number of individuals of many species regenerate, but only a few succeed and grow into adults because of quick bamboo re-establishment. This stagnates succession in (species-poor) early succession forests. Because of its widespread distribution in southern Brazil, bamboo management should be integrated into forest conservation practices.

Climate change impacts on forests and biodiversity in Western Himalaya of Nepal. Lamichhane, D. (*Ministry of Forest and Soil Conservation, Nepal; dlamichhane@gmail.com*), Silwal, A. (*HELVETAS, Nepal; anjali.silwal@helvetas.org.np*).

Forest resources and biodiversity in the Himalayan region of Nepal are considered as more fragile mainly due to climate change and other anthropogenic causes. The research was conducted in the remote mountainous region of western Nepal to analyze the climate change impacts on forests and biodiversity. Socioeconomic data were collected using semi-structured questionnaires, focus group discussions, and checklists, while forest and biodiversity-related data were collected through direct field observation, plots establishment and measurement, and field experiments. Results indicated that the rising temperatures, glacial retreat and the changes in the availability of water resources affected a considerable number of globally important plant and wildlife species in the region. Other impacts, such as a high rate of snow melting, caused the tree line to shift up, the biodiversity to narrow down, and downstream flooding. Forest degradation and biodiversity loss had largely affected agricultural crops production, livestock farming with low availability of grazing area and forage, and livelihood assets in the Himalayan region. The adaptive strategies by local people included activities like altering the timing of planting of crops, changing crop types, controlling insect outbreaks, and breeding new agricultural and forest species that would be better suited to the changing climatic conditions.

Performance and potential of landscape level biodiversity conservation for climate change adaptation and mitigation in Nepal. Lamsal, R. (*Ministry of Forests and Soil Conservation, Nepal; ramplamsal@gmail.com*), Khanal, S. (*Kathmandu University, Nepal; sanjay@ku.edu.np*).

Landscape approach in conservation has gained prominence to reconcile conservation and development tradeoffs and tends to generate impacts not only on conservation of biodiversity and ecosystem services, improvement of livelihoods, but also on climate change. This study, which focuses on the Terai Arc Landscape (TAL) area of Nepal, addressed the following: (a) discusses linkages between biodiversity and climate change adaptation and mitigation; (b) reviews observed and perceived impacts of climate change; (c) offers some community-based mitigation and adaptation techniques; and (d) discusses issues on identification and assessment of impacts. The study is based on literature review, field visits, case studies, and relevant participatory tools and techniques. This study illustrates the practice, outcomes, and future potential of landscape level conservation in Nepal as an approach to achieving conservation and livelihood goals and supporting climate change adaptation and mitigation. It presents cases where communities are using various strategies to improve biodiversity conservation and natural resources management to minimize the negative impacts; reveals potentiality of mitigation through biodiversity conservation and sustainable forest management; and finally presents a community-based assessment framework, methodology, and tools dealing with vulnerability and climate change.

The carbon footprint of forestry in east Norway: a life cycle analysis. Lange, H., Timmermann, V., Dibdiakova, J., Gobakken, L. (*Norwegian Forest and Landscape Institute, Norway; holger.lange@skogoglandskap.no; tiv@skogoglandskap.no; JAD@skogoglandskap.no; gol@skogoglandskap.no*).

A wide range of forest products and industries have been examined in life cycle analyses (LCA). Life cycle data are essential for identifying forestry operations that contribute most to carbon emissions. Forestry can affect net CO_2 emissions by changing carbon stocks in biomass, soil, and products, by supplying biofuels to replace fossil fuels as well as by establishing new forests. The transport of forest products is crucial to greenhouse gas (GHG) emissions. We conceptualize the chain from seed production, silviculture, harvesting, and timber transport to the industry as a system. Inputs to the system are energy and fuel, the output represents GHG emissions. The reference functional unit used for the inventory analysis and impact assessment is one cubic meter of harvested timber under bark. GHG emissions from forestry in East Norway were calculated for the production of one such unit delivered to the industry gate in 2010 (cradle-to-gate inventory), showing that timber transport from the forest to the final consumer contributed with more than 50% to the total GHG emissions. To assess uncertainty of model approaches, the LCA was conducted with two different models, SimaPro and GaBi, both using the Ecoinvent database with data adapted to European conditions.

Estimating and extracting the optimal parameters of random walk model for debris flow hazard mapping. Lee, C. (*Korea Research Institute, Republic of Korea; leecw@forest.go.kr*).

Random walk model can predict the sediment areas of debris flow, but three fitted topographical environment parameters must be extracted. This study developed the method to extract the optimal values of three parameters, once flowing volume, stopping slope, and gravity weight, for the random walk model. Extracted parameters were validated by aerial photographs of the debris flowed area. Extraction of the optimal parameters was randomly performed, limiting the range values of three parameters and developing an accuracy decision method that is called the rate of concordance. In order to apply to other sites, we need to development estimation methods by pseudo sample neural network (PSNN). PSNN is a variant of traditional neural network using pseudo samples based on existing training samples to mitigate the local-optima-convergence problem when the size of training samples is small. PSNN can take advantage of the smoothed solution space through the use of pseudo samples. PSNN focuses on the quantity problem in training, whereas, methods stressing the quality of training samples is presented in this paper to improve further the performance of PSNN.

Effects of plug cell trays, soil components, and shading rates for seed germination and growth of *Hippophae rhamnoides*. Lee, S., Kang, H., Cho, W. (*Dongguk University, Republic of Korea; i871214@hanmail.net; hdk0225@dongguk.edu; valkyre@naver.com*).

Hippophae rhamnoides, a member of Elaeagnaceae, is gaining popularity at home and abroad ever since its beneficial effects were introduced. Seabuckthorn doesn't grow well in Korea and problems are being encountered in raising seedlings due to indiscriminate introduction of high value species and lack of skills and knowledge. Therefore, this study was conducted in field conditions in order to disseminate the cultivation method amongst tree growers. Chinese seeds had a relatively high germination rate in 128 cell traya and grew well in 50 cell trays, whereas the Russian seed had relatively high germination rate and growth

rate in 50 cell trays. In terms of soil type, both the Chinese and the Russian seeds showed less than 20% germination rate in weathered granite soil and the growth rate was also the lowest. Chinese seeds had high germination rates in TKS-2 and the Russian seeds in horticultural substrate, respectively. The growth rates of Chinese and Russian seedlings were high in TKS. Chinese seed had the highest germination rate in controls and shoots grew well at 70% shading, whereas the roots grew well in full sunlight. Russian seed had about 50% germination rate at 30% and 70% shading. Support of Forest Service and Technology Projects (Project No. S120911L120110 and S211213L030110) provided by Korea Forest Service.

Dieback of evergreen coniferous forests due to climate change in Korea and their management options for adaptation. Lim, J. (*Korea Forest Research Institute, Republic of Korea; limstree@hanmail.net*), Lee, D. (*Seoul National University, Republic of Korea; leedk@snu.ac.kr*), Suh, S. (*Chubgbuk National University, Republic of Korea; suhs77@hanmail.net*).

Climatic warming, especially warmer and drier winters, exacerbate decline of evergreen coniferous forests in Korea, in addition to pressures of insects and successional trends. Following mass mortality of pines in 1998, 2002, and 2007, more than 1 million trees were dead in 2009 due to drought and warm winter climate especially in southern areas of its distribution range. While deciduous *Larix leptolepis* and broadleaved trees survived, mass mortality occurred on dense unmanaged *Pinus koraiensis* plantations and on dense natural *Pinus densiflora* stands on southern slopes. Drought and warm winter temperatures promoted the pathogenicity of *Cenangium ferruginosum.* According to the projected changes of seasonal climate by IPCC-SRES models, air temperature will increase more rapidly in winter than summer, while precipitation is variable and uncertain. In the future, diebacks of evergreen conifers due to drought stress in winter are anticipated to occur more frequently in Korea. Thus, evergreen coniferous forests in Korea are potentially more vulnerable to future climate change impacts, primarily due to increasing winter temperatures. Significance and silvicultural options, including thinning and planting species selected for the adaptation of conifer forests to climate change, is discussed.

The Mica Creek project: a comprehensive assessment of environmental effects of contemporary harvest practices in the interior Pacific Northwest, USA. Link, T. (*University of Idaho, USA; tlink@uidaho.edu*), Gravelle, J. (*PineOrchard, Inc., USA; jag@pineorchard.com*), Hubbart, J. (*University of Missouri, USA; HubbartJ@missouri.edu*), Karwan, D. (*University of Minnesota, USA; dlkarwan@umn.edu*), Du, E. (*Lawrence Berkeley National Laboratory, USA; edu@lbl.gov*).

The Mica Creek Project in northern Idaho is a comprehensive monitoring program to fill the critical knowledge gap concerning the environmental effects of contemporary forest harvest practices. The experiment employed paired and nested watersheds at multiple scales in a before-after, control-impact (BACI) study design. The experimental period consisted of pre-treatment calibration, post-road construction, and post-harvest phases. Specific results of the study indicated that stream flows increased significantly by ~30% in the harvested areas following timber harvest. Hydrologic modeling indicated that annual yields and flow regimes were relatively insensitive to harvest patterns, relative to total area harvested. Stream temperatures increased by several degrees in some harvested headwater reaches but were unchanged in others and downstream of harvested areas. Riparian shade in many reaches recovered rapidly as a result of low-growing herbaceous vegetation. Suspended sediment loads increased following harvest but returned to background levels within a year. Nitrate concentrations in stream water were very low but increased by roughly an order of magnitude following post-harvest burning. There was generally no change in the macroinvertebrate community structure resulting from timber harvest. Fish occurrences increased slightly and were found to expand upwards in the stream network following harvest, possibly as a result of increased flows and/or food abundance.

Density and regeneration of *Carapa guianensis* Aublet. in floodplain forests of the Amazon estuary in Amapá State, Brazil. Lira-Guedes, A., Guedes, M.C. (*EMBRAPA, Brazil; ana.lira@embrapa.br; marcelino.guedes@embrapa.br*), Pinto, E. R. (*Federal University of Amapá, Brazil; pemanuelle@yahoo.com.br*).

Carapa guianensis Aublet. is an important species of multiple use in Amazon. Besides the timber, considered noble, its seeds provide oil with high medicinal and cosmetic value. In the Amazon estuary floodplains, the crabwoods were intensively exploited. We compared the density (DBH≥10 cm) and regeneration (5–10 cm) of crabwoods in estuarine floodplain forests along the Amazon River (Amapá State). We conducted 100% inventory (DBH≥10 cm) in Mazagão Novo (56 ha) and the Fazendinha Protected Area (136.6 ha). We inventoried (DBH≥5 cm) 80 plots of 10 m × 25 m at each site in Mazagão Velho, Maraca, and Ajuruxi. Densities in Mazagão Novo, Fazendinha, Mazagão Velho, Maraca, and Ajuruxi were 3, 6, 6, 8, and 18 trees/ha, respectively. The lowest densities can be attributed to locations closer to urban perimeters and timber marketing centers. The sampling may overestimate the crabwood population due to its clumped distribution. The percentage of juveniles (DBH 5–10 cm) in Mazagão Velho, Maraca, and Ajuruxi were 32%, 27%, and 41%, respectively, indicating a good regeneration capacity. The Ajuruxi region, which is more isolated and located within a conservation unit (Resex Cajari), had the highest density and regeneration, demonstrating that the protected area may also have contributed to the abundance of crabwoods.

Climatic Effects on Teak Growth in Northern Thailand. Lumyai, P., Duangsathaporn, K. (*Kasetsart University, Thailand; fforpcl@ku.ac.th; fforkcd@ku.ac.th*).

The purpose of this research was to investigate the relationship between teak growth and climate data in local, regional, and global scales. The standard techniques of dendrochronological study were used to analyze 36 sample cores from Thampathai National Park. The crossdated ring width data could be extended back to 125 years (1888–2012). In Umphang Wildlife Sanctuary, a total of 35 cores from 20 trees were successfully crossdated. The crossdated ring width data could be extended back to 124 years from 1889–2012. The relationship between ring-width index and climatic data indicated the positive correlation of teak growth in Thampathai National Park with rainfall in April–May and indicated the positive correlation of teak growth in Umphang Wildlife Sanctuary with rainfall in June. Results revealed the beginning period of the rainy season which had effects on teak growth in northern Thailand. In the case of tree growth regional and global climatic relationship, the southern oscillation index (SOI) and sea surface temperature (SST) were significantly correlated with teak growth in Umphang Wildlife Sanctuary. Therefore, teak is a reliable recorder of rainfall during the beginning of the rain season and can be applied to investigate the droughts and periods of great diminution in the past.

The chain of climate change, forest fires, runoff and erosion: key processes, mitigation prospects, and information needs. MacDonald, L. (*Colorado State University, USA; lee.macdonald@colostate.edu*).

Climate change is projected to increase the number, size, and severity of wildfires. High severity fires are already a major concern in many forested areas because they can increase peak flows and erosion rates by several orders of magnitude, with resulting adverse effects on water quality and other aquatic resources. The objectives of this paper are to: (1) provide a process-based understanding of the observed increases; (2) use this understanding to help predict post-fire erosion risks, recovery rates, and the effectiveness of various post-fire mitigation treatments; and (3) identify key information needs from both a research and a management perspective. Recent studies have identified the loss of surface cover and changes in soil erodibility as the key controlling factors rather than canopy loss or post-fire increases in soil water repellency. The critical role of ground cover is supported by studies showing that mulching is the most effective treatment for reducing post-fire erosion. Rainfall intensity is the other key control, necessitating a stochastic rather than deterministic modeling approach. The most urgent research and management need is to determine how hillslope-scale changes can be aggregated and routed to the watershed outlet, as this is the key scale for resource managers.

Interaction on land use changes to hydrological characteristics of Mae Klong Head watershed, western Thailand. Marod, D., Kamyo, T. (*Kasetsart University, Thailand; dokrak.m@ku.ac.th; torlarp66@yahoo.com*), Yarnuvdhi, A. (*Center for Advanced Studies in Tropical Natural Resources, National Research University, Thailand; psdaryv@ku.ac.th*), Panuthai, S. (*Department of National Parks, Wildlife and Plant Conservation, Thailand; newsam@3bbmail.com*), Hiroshi, T. (*Forestry and Forest Products Research Institute, Japan; hirop@affrc.go.jp*).

The interaction on land use changes and hydrological characteristics was conducted at LinThin watershed, Kanchanaburi Province. Changes in forest area cover was monitored by satellite images of LANDSAT TM from three phases (1992, 2000, and 2008). The meteorological and hydrological data from 1994 to 2011 were analyzed. The hydrological data was divided into three phases based on their cyclical period, 1994–1999, 2000–2005, and 2006–2011, for detecting the response on land use changes. The results showed average annual rainfall was 1 662.6 mm, and it provided stream flow of 552 513 m^3/km^2. Potential stream flow of the watershed was 33.2% of total amount rainfall. The stream flow was a higher percentage in wet the period than dry period at 73.5% and 26.5%, respectively. The highest forest covered area found in 1992 to 2000 was about 74.2%, whereas from 2000 to 2008 it was10.6%. The annual stream flow and flow during the wet period tended to decrease from first to third phase when the forest areas increased. In contrast, flow tended to increase during the dry period, indicating that increasing forest area covered led to decrements in 5% and 1% intervals of the stream flow. It regulated flooded and water shortage during wet and dry periods.

The role of poplar plantations on biodiversity in riparian landscapes. Martín-García, J. (*University of Valladolid, Spain; jorgemg@pvs.uva.es*), Jactel, H. (*National Institute for Agricultural Research, France; herve.jactel@pierroton.inra.fr*), Diez-Casero, J. (University of Valladolid*, Spain; jdcasero@pvs.uva.es*).

In Mediterranean areas, riparian zones are particularly important for maintaining biodiversity. Nevertheless, the native vegetation in these zones has been modified or lost at an alarming rate during the last decades. The main objective of this study was to investigate the influence of poplar plantations on biodiversity in riparian zones in order to estimate the ecological implications of a substantial expansion of poplar plantations. The studies were carried out in three different taxonomic groups, including macroscopic life forms (birds and vascular plants) and microbial diversity (endophyte fungi). Towards this purpose, a wide variety of both poplar plantations and the remnant patches of natural riparian forests were surveyed. Breeding birds and vascular plants were sampled by the point-count and quadrant methods, respectively. Endophytes were identified according to sequences of the ITS region of their rDNA. These studies showed marked differences on species, structural, and functional diversity between poplar plantations and native forests. This suggests that poplar plantations should not be used as surrogates for native forests. Nevertheless, poplar plantations can still accommodate rich biodiversity, providing that suitable management is applied at local (minimizing the use of harrowing) and landscape levels (increasing the percentage of poplar plantations in relation to other crops).

Frost pocket effect results in severe canopy damage in a Mediterranean-type forest in southwestern Australia. Matusick III, G., Ruthrof, K., Brouwers, N., Hardy, G. (*Murdoch University, Australia; G.Matusick@murdoch.edu.au; K.Ruthrof@murdoch.edu.au; n.brouwers@murdoch.edu.au; g.hardy@murdoch.edu.au*).

Alterations to the frequency and intensity of extreme temperature events, predicted with climate change, pose a threat to the health forest trees in many areas of the world. Although global climate models predict Mediterranean climate regions are expected to get warmer with climate change, recent evidence suggests southwestern Australia may experience more frequent extreme cold events due to regional climate drivers. To determine the impact of extreme cold temperatures on forest vegetation in southwestern Australia, a study was initiated following the onset of frost damage in 2012. From an aerial survey, frost affected sites were found more frequently in valleys and lower to mid-slope positions compared to unaffected sites. Results from transect sampling along elevational gradients confirmed increasing tree crown damage with decreasing elevation and air temperature. Results from regression analysis suggest air temperatures reached a minimum of –2.7 °C in the zone of affected forest when the damage occurred. Dominant canopy species *Eucalyptus marginata* and *Corymbia calophylla* were both severely affected, though differences in symptomology were observed. This research confirms forest trees in Mediterranean climate regions are susceptible to severe damage from extreme cold temperatures, which could significantly impact forest health if climate change increases the frequency of cold temperature events.

Fine woody debris (FWD) and biodiversity in managed forests: effects of the spatial distribution of FWD on invertebrates, small vertebrates, fungi, and plants. McCavour, M. (*Concordia University/Université de Québec à Montréal, Canada; mccavour@gmail.com*), Messier, C. (Université du Québec en Outaouais, *Canada; ch.messier@gmail.com*).

We evaluate the role of fine woody debris (FWD) in the maintenance of biodiversity in managed high-latitude forests, with an emphasis on the effect of the spatial distribution of slash. Further, we contrast the degree of FWD aggregation in intensive management vs. varied types of natural disturbance, distinguishing between FWD used as shelter, substrate, nutrition, or (indirectly) as an enhanced source of light. Taxa examined include cryptogams, invertebrates, vertebrates, and plants. We find that, overall, the taxa most sensitive to FWD removal are fungi and plants. Aggregated FWD especially benefits shade-intolerant plants, small vertebrates, and some cryptogams, though all taxa had examples with a positive response to more evenly-dispersed slash. We propose that aggregated slash mimics the role of small canopy gaps by increasing deadwood input and soil nutrition and maintaining high light levels for extended periods. Further, this delayed canopy closure means that piles and windrows, like gaps, enhance flower and fruit production, and thus serve as crucial foraging sites for pollinators and frugivores. Concluding that FWD retention is an important element in biodiversity maintenance in industrial forests, we discuss the potential for using local natural disturbance regimes as a template for decisions on slash retention and spatial distribution.

Interspecific tree competition and functionality in tropical dry forest environments in the Alto Magdalena region, Colombia, South America. Melo Cruz, O., Rodríguez Santos, N., Fernandez Mendez, F. (*University of Tolima, Colombia; omelo@ut.edu.co; natha8902@hotmail.com; fmendez@ut.edu.co*).

This study presents findings about environmental conditions for growth and interspecific tree competition in three types of tropical dry forests in the region of Alto Magdalena (Colombia). The sample areas were located in sections of natural vegetation of forests on hillocks (bosque de Lomerío – BL), hills (bosque de colinas – BC) and riversides (bosque rivereño – BR). In each area, four monitoring plots of 0.25 ha were established. Competition was evaluated by means of crown indices and illumination by canopy openings for individuals with a DBH (diameter at breast height) of more than 5 cm. The values obtained were related to the surrounding canopy. Canopy openings were determined by means of hemispherical images and related to the values of photosynthetically active radiation recorded with a quantum radiometer (LI-191). The densest canopy was found on the BC plots with 1 134 trees/ha, whereas the BR and BL plots had 365 and 794 individuals, respectively. Vertical and lateral illumination was recorded in 55% of the individuals of the BL canopy, as compared to 39% of the BR and 70% of the BC canopies. In conclusion, it was found that the BC plots showed higher interspecific competition values than the BR and BL plots, which suggests differential management and conservation strategies for these forest covers.

Assessment of management effectiveness of six national forests in Brazil. Mendonça, S.D., Junior, L.D.C., Tetto, A., Batista, A. (*Federal University of Paraná, Brazil; dmsabina@hotmail.com; ldonizeti2@gmail.com; tetto@ufpr.br; batistaufpr@ufpr.br*).

The establishment of National Forests in the south of Brazil aimed to develop sustainable use of forest resources along with protection of Atlantic Forest remnants. Assessing the management effectiveness of these areas is as important to nature conservation as the creation of new ones. In this study, six national forests in the south of Brazil had their management efficiency assessed through WWF's Rapid Assessment and Prioritization of Protected Areas Management (RAPPAM) methodology. The most recurrent pressures and threats were invasion of alien species, hunting, and waste disposal (pollution). Weaknesses observed were low financial resources and flaws in the national protected area system, including lack of commitment and financial resources, low communication among institutions, and no national policies promoting widespread environmental education at all levels. Other weaknesses in the system were: lack of revision of the system (probably due to its incipiency) and no assessment of the historical range of variability of ecosystem types in the region. According to RAPPAM parameters, the national forests assessed displayed high efficiency (64%). Despite the good overall results shown by the areas, the assessment brings to light the challenges that should be faced by the present political system in order to achieve better conservation standards.

Knowing the past to anticipate the future: soil charcoal as a proxy to model the evolution of tropical forests. Morin-Rivat, J., Biwolé, A., Bourland, N., Dainou, K., Fayolle, A. (*University of Liège – Gembloux Agro-Bio Tech, Belgium; jmorin@doct.ulg.ac.be; achille.biwole@doct.ulg.ac.be; nils.bourland@aigx.be; kdainou@ulg.ac.be; adeline.fayolle@ulg.ac.be*), Gillet, J., Gorel, A., Hardy, O, Vleminckx, J., Doucet, J., Beeckman, H.

Tropical forests of Central Africa constitute the second most important block of moist forest of the world. However little is known about their past evolution. Indeed, determining the past specific composition of these forests could allow modeling their evolution over time and providing data about their resilience capacity facing global change. To do this, we performed a pedoanthracological analysis in the semi-deciduous forests of southeastern Cameroon. We excavated test pits in 53 plots of botanical inventory along a gradient of vegetation, quantified wood charcoals by layers of 10 cm, identified the species present in charcoals, dated the charcoals by the radiocarbon method, then built up sequences including present forest composition. Results show that repeated fire events occurred across the study area during the last 2 500 years. These disturbances are likely human-induced regarding evidence of anthropogenic activities (e.g., potsherds). Nonetheless, the past specific composition does not strongly differ from the current one except for the oldest layers related to the major dry climatic event of 2500 BP. We conclude that moist forests have a good resilience capacity regarding moderate disturbances but were and will be deeply impacted by climate change.

Water volume and sediment impacts of forest-based biomass site preparation and planting. Nettles, J. (*Weyerhaeuser Company, USA; jami.nettles@weyerhaeuser.com*), Chescheir, G. (*North Carolina State University, USA; cheschei@ncsu.edu*), Amatya, D. (*U.S. Forest Service, USA; damatya@fs.fed.us*).

To quantify the potential environmental impacts of forest-based biofuel systems, Catchlight Energy LLC, a Chevron|Weyerhaeuser joint venture, established a study of the sustainability of biomass cultivation in managed forests, with soil productivity, carbon life cycle, biodiversity, and water resource components. The water resource component is being conducted primarily on three sets of forested watersheds in North Carolina, Mississippi, and Alabama. Each sub-watershed (10–30 ha) is instrumented to provide data on precipitation, stream discharge, weather, groundwater table, and water quality. In addition to these long-term watershed studies, smaller scale plots are installed in Lenoir County, NC. Biomass treatments were applied to the large watershed studies in 2012–2013. These treatments represent a range of operational intensities, from traditional pine plantation management, to intercropping,

to switchgrass only plantings. The sites also span a range of operability, from coastal North Carolina to the higher slopes and more erodible soils of Northern Mississippi. With data from one year post-site prep and planting at most large watershed sites, preliminary comparisons can be made between treatments and sites. This presentation is an overview of the results, focusing on hydrology and sediment impacts.

Maintenance of urban forest biodiversity of Boa Vista, North Amazon, Brazil. Neto, E.L., Pinheiro, F., Reisq, F. (*State University of Roraima, Brazil; everaldo.limaneto@gmail.com; flavia_abreu@hotmail.com; flr_77@hotmail.com*), Batista, D.B. (*Federal University of Paraná, Brazil; dbiondi@ufpr.br*).

The indiscriminate use of alien species in urban forestry can generate impacts on regional biodiversity and cultural aspects involved with species native to your area. The aim of this study was to analyze the floristic composition of the city of Boa Vista to suggest the inclusion of native species and regular local biodiversity. Census conducted inventory of trees on the sidewalks of the city of Boa Vista found the presence of 91 tree species distributed in 69 gender and 30 botanical families. Of these, nine species represent 85% of the individuals used in forestry, of which 53.5% are exotic species and 46.5% are native to Brazil. Although the number of exotic species is slightly larger than the native, one can consider that the urban trees of Boa Vista still prioritize native species. Considering that in Brazilian cities it is common for more than 70% of afforestation to be composed of exotic species, it is concluded that the results obtained in this study are very positive. Therefore, it is recommended that those responsible for planning the urban trees of Boa Vista should be encouraged to maintain or enhance the rate of species native to the city.

The role of landscape connectivity on terrestrial mammal conservation in a fragmented tropical rainforest. Nicasio, S., Benítez-Malvido, J. (*National Autonomous University of Mexico, Mexico; snicasio@cieco.unam.mx; jbenitez@cieco.unam.mx*).

The biodiversity conservation into fragmented tropical rainforests relies on multi-scale factors which affects their survival. The presence of terrestrial frugivorous mammals is key for plant diversity conservation due to their ecological functions as seed dispersers and seed predators. Landscape connectivity is pivotal for alleviating the effects of fragmentation on these mammals, whose movements between fragments are restrained by the landscape matrix. Despite its importance, the connectivity assessments have not been addressed in tropical areas. In this study, we used satellite imagery and network metrics to assess the landscape's connectivity in a frugivorous mammal community ($\geq$ 1 Kg) into a fragmented rainforest at southern Mexico. The matrix resistances were estimated through different vegetation indexes (ARVI, EVI, MI, NDVI) and the connectors strength between fragments were quantified by the methods of least-cost path and circuit theory. These connectivity models were tested with field data of the community composition. Our results showed that the patches of semiaquatic vegetation and secondary forests are key to maintaining the landscape connectivity for this mammal community. Some management guidelines for connectivity conservation within these fragmented rainforests are suggested.

Removing forest harvesting residuals: effects on biodiversity and species composition in Norwegian forests. Økland, T., Nordbakken, J., Lange, H., Røsberg, I., Kjønaas, O. (*Norwegian Forest and Landscape Institute, Norway; tonje.okland@skogoglandskap.no; jfn@skogoglandskap.no; holger.lange@skogoglandskap.no; roi@skogoglandskap.no; kjo@skogoglandskap.no*), Clarke, N., Hanssen, K.

Harvesting of forest residues (branches and tops) for bioenergy use may lead to biodiversity loss and changes in species composition in forest ground vegetation, which in turn also will affect soil properties. Short-term effects have been analyzed at two boreal sites dominated by *Picea abies* in Norway (one site in SW and one in SE). Whole tree (WTH) and stem-only (SOH) harvesting have been performed recently here. Long-term effects have been analyzed at two other experimental sites, where whole-tree thinning and stem-only thinning were performed 30–40 years ago. In each of the vegetation plots established at these sites, percentage cover of each species as well as environmental variables (topographical, soil physical, soil chemical, and tree variables) were recorded. Effects of different harvesting methods on plant biodiversity for several species groups were analyzed, as well as effects on species composition. Short-term effects seem to be considerably related to remnant residuals and to the more uneven distribution of residuals at WTH plots (due to piles of residuals left on the sites). Long-term effects of whole-tree thinning on vegetation will also be presented.

Validation of a landscape-scale habitat suitability model and map for the Oregon slender salamander. Olson, D. (*U.S. Forest Service, USA; dede.olson@oregonstate.edu*), Suzuki, N. (*University of Northern British Columbia, Canada; nobi.suzuki@gmail.com*).

Retention of forest-dependent species with small ranges and low dispersal, such as the Oregon slender salamander (*Batrachoseps wrighti*), is a challenge in a multi-use landscape inclusive of timber harvest. To aid development of species-conservation priorities for Oregon slender salamanders on the west slope of the Oregon Cascade Range on federal lands, we developed a landscape-scale habitat suitability model and projected four habitat suitability classes (low, moderately low, moderate, and high) onto a map. We field-validated the model by surveying randomly selected sites within each of the four habitat classes. We detected Oregon slender salamanders at a large proportion (76%) of sites within either the high or moderate habitat suitability class. Zero-inflated negative binomial regression analyses and 95% confidence intervals verified that significantly high nondetection rates were associated with the low habitat suitability class, whereas significantly high detection rates were associated with the moderate and high habitat suitability classes. The model correctly classified 67% of field-validation data. Our model and map are useful to define geographic areas for further development of combined conservation and timber harvest priorities.

Spatial characteristics of physicochemical parameters of a reservoir adjoined by degraded watershed forest. Oyebola, O., Akinyele, A. (*University of Ibadan, Nigeria; olusegun.oyebola@yahoo.com; akinyelejo@yahoo.co.uk*).

Asejire reservoir in southwestern Nigeria was adjoined by a degraded watershed. Spatial characteristics of its physicochemical parameters were investigated through a 2 year bi-monthly water sampling of 38 sites for mean values, variability, and limiting spatial values (LSV) of temperature, dissolved oxygen (DO), pH, alkalinity, and hardness. Percentage of sites showing LSV was

documented per parameter for seasons. The LSV sites were related with degraded watershed using Geographic information Systems technique. Range of wet and dry season values of temperature, DO, pH, Alkalinity and hardness were: 27.50±2.50-29.67±1.89 and 27.4±1.78- 30.13±2.37 °C; 4.63±0.64-7.60±0.36 and 4.23±0.61-7.97±1.84 mg/l; 7.10±0.17-7.53±0.31 and 7.10±0.61-7.88±0.24; 55.33±37.65-74.67±21.94 and 80.67±47.93-123.33±47.39 mg/l; 44.00±5.29-60.00±24.33 and 39.33±5.03-64.00±6.00 mg/l respectively. Range of percentage variability in wet and dry seasons values of temperature, DO, pH, alkalinity and hardness were: 6.37-9.09 and 6.5-7.87; 4.74-13.82 and 14.42-23.09; 2.39-4.12 and 3.05-8.59; 29.38-68.04 and 38.43-58.41; 12.02-40.55 and 9.38-12.79 respectively. LSV did not occur in pH but was observed in 52.63% sites in dry season temperature values, in wet and dry seasons DO, hardness and alkalinity with percentage sites: 7.89 and 18.42; 100 and 84.21; 13.16 and 2.63 respectively. The study implied that variation and LSV of water quality parameters characterized aquatic environment adjoining degraded watershed.

Effect of woody and shrub plants with different patch size on selected soil chemical properties in semi-arid lands. Özçelik, M., Şengönül, K., Gökbulak, F., Uygur, B. (*Istanbul University, Turkey; msaid.ozcelik@istanbul.edu.tr; sengonul@istanbul.edu.tr; fgokbulak@istanbul.edu.tr; uygurb@istanbul.edu.tr*).

The purpose of this study was to examine effects of woody and shrub plant populations with different patch sizes on soil chemistry in a semi-arid region. Study site was located in the semiarid mid-northern part of Turkey (40° 33′-40° 51′ N and 33° 17′-33°46′E). Effect of two types of plant groups woody and shrub species) with three different patch sizes (radius <4 m, 4–8 m, >8 m) were studied. Woody plant populations were mainly composed of Caucasian oak (*Quercus macranthera* Fish et Mey. *subsp. syspirensis* (C.Coch.) Menitsky.) whereas shrubs consisted of Blackthorn *(Paliurus spina-christi* Miller). In order to investigate patch size impacts, soil samples were collected from topsoils under the plant canopies and surrounding areas adjacent to plant canopies. Soil samples were analyzed for pH, electrical conductivity, organic matter, N, P, K, Mg, and Ca. Results showed that woody and shrubs populations with different patch sizes did not differ significantly in terms of their impacts on soil chemistry under the canopies and surrounding areas. Based on results of this study, these plant populations with current patch sizes can be cleared in the site preparation in land rehabilitation works if necessary due to insignificant influence on soil fertility.

Small scale distribution in ground-dwelling arthropods reveals big picture patterns. Pinzon Cortes, J., Spence, J. (*University of Alberta, Canada; jpinzon@ualberta.ca; john.spence@ualberta.ca*), Bourassa, S. (*Canadian Forest Service, Canada; sb22@ualberta.ca*), He, F. (*University of Alberta, Canada; fangliang.he@ualberta.ca*).

Spatial distribution of species over large areas is of great interest for forest managers and conservationists. Consequently, increasing research efforts have been applied to understand factors that determine and influence large-scale patterns. Patterns at the small scale are less studied, but we hold that they are equally important to conservation of biodiversity. We address this issue by studying relationships between local distributions of ground-dwelling arthropods and those of understory and overstory layers of the forest within a 1-ha permanent plot of never-cut forest in central Alberta (Canada). All stems (alive and dead) greater than 5 cm in diameter at breast height were mapped within the plot using a total station, and species identities were recorded. Percent cover by species of understory vegetation were also recorded, and epigaeic arthropod samples were collected from the ground using evenly spaced pitfall traps. Results show that microhabitat variation at a small spatial scale has an important influence in determining the distribution of highly mobile organisms such as spiders and carabid beetles, and through other work, we know that such variation is homogenized with prevailing forest practices. Biodiversity depends on such variation, and only through understanding it will we be able to conserve it.

Structure and floristic composition of the cloud forest on Cocos Island National Park. Porras Jiménez, M., Acosta Vargas, L., Castillo Ugalde, M., Quesada Monge, R. (*Costa Rica Institute of Technology (ITCR), Costa Rica; mapjcr82@gmail.com; lacosta@itcr.ac.cr; mcastillo@itcr.ac.cr; rquesada@itcr.ac.cr*).

During 2012, in Cocos Island National Park, six permanent sample plots of 2 500 m^2 were established near the hills of Yglesias and Pelón (630 and 560 musl) where humidity and cloudiness favor a type of plant association considered the cloud forest, and at lower altitudes between 300 and 630 musl. Total height, position, cup-shaped of lianas were measured for all individuals with a diameter greater than 5 cm at 1.3 m above ground. Sixteen plant species were found of which five were endemic. Species diversity relative to the vertical structure decreased from 14 in the lower canopy to 5 in the canopy. *Sacoglottis holdridgei* is the only species with continuous horizontal and vertical distribution. The abundance was 1653 ± 80 tree/ha. *Cyathea alfonsiana* was densest (1202 tree/ha) in the first diameter class. The basal area was 21.53 ± 0.74 m^2/ha, with 23% corresponding to C. *alfonsiana* and 62.5% corresponding to *S. holdridgei*. Both importance value indices of some species, such as the diversity indices showed significant differences compared to the altitude. The behavior of the species, altitude, and climatic conditions of the site allow estimation of the structural dynamics and composition of these populations as an indicator of climate change effects.

Does biodiversity make a difference? evolutionary diversity indicators of forest ecosystem function across broad regions. Potter, K. (*North Carolina State University, USA; kpotter@ncsu.edu*), Woodall, C. (*U.S. Forest Service, USA; cwoodall@fs.fed.us*).

Biodiversity conveys numerous functional benefits to forested ecosystems, including community stability and resilience. Biodiversity metrics that account for evolutionary relationships among species may be better surrogates for functional diversity than traditional measures such as species richness. We conducted two broad-scale studies that applied measures of evolutionary diversity to assess forest function. In one, we assessed trends in live aboveground tree biomass (LAGB) in relation to tree biodiversity calculated on 79 000 Forest Inventory and Analysis plots across the United States, controlling for site productivity and live tree stocking. We found that biodiversity was more closely associated with greater LAGB on low-productivity sites with low tree stocking. This is consistent with the expectation that the coexistence of functionally different species increases forest productivity in less productive and more stressful environments, while dominant and highly productive species are able

to competitively dominate in more productive habitats. In a second study, we tracked regional changes in forest community biodiversity separately for trees and seedlings on FIA plots across broad regions of the eastern United States. We detected broad-scale patterns of forest evolutionary diversity change that are consistent with expected early effects of climate change. Such changes could alter the ecological functions of forest communities.

Ecological role of forests fragments in Antananarivo urban area. Rabenilalana, F., Rakoto Ratsimba, H., Ratovoson, A., Rakoto Ratsimba, P. (*University of Antananarivo, Madagascar; rmihajamanana@yahoo.fr; rrharifidy@moov.mg; rainanavale@yahoo.fr; percyyvon@gmail.com*), Bogaert, J. (*University of Liège/Gembloux Agro-Bio Tech, Belgium; j.bogaert@ulg.ac.be*).

Most of natural evergreen type vegetation in the central plateau has been cleared and modified by anthropogenic activities. Some large blocks still persist and the most important are located at Ambohitantely and Mandraka areas. These forests are the remnants of the center Ecoregion forest ecosystem, and they still have a wide range of biodiversity which plays a crucial role for urban areas. The setting up of a protected areas system does not prevent some types of threats and pressures on these ecosystems. This research analyzes the temporal and spatial variability of fragments in these blocks of forests and their impacts on biodiversity. LANDSAT satellite images have been used to study the evolution and the intensity of the fragmentation during the last thirty years. Biological data on the fauna and flora have also been assessed. The results show that the process of fragmentation is increasing and is linked to anthropogenic pressures growing in the study area. These spatial data will serve as the basis for decision makers and to the local communities in order to implement new initiatives of forest restoration for biodiversity conservation.

Can capturing global ecosystem service values reduce poverty? Ramamonjisoa, B. (*University of Antananarivo, Madagascar; bruno.ramamonjisoa@gmail.com*), Gordon Jones, J. (*Bangor University, United Kingdom; julia.jones@bangor.ac.uk*), Schreckenberg, K. (*University of Southampton, United Kingdom; k.schreckenberg@soton.ac.uk*), Ranjatson, J. (*University of Antananarivo, Madagascar; pranjatson@yahoo.fr*).

There has been a recent explosion of interest in market mechanisms to capture global ecosystem service values. An argument in their favor is that they can, in principle, benefit the poor by increasing the value of their resources. However, the effect on poverty is not easily predicted and depends on the structure and distribution of payments and how land-use changes driven by the payments influence the supply of locally important ecosystem services and livelihood options to poor people. How can international ecosystem service payment schemes (specifically for carbon sequestration/storage and biodiversity conservation) most effectively reduce poverty in low income countries, given biophysical, economic, and political realities? There have been few, if any, detailed multi-dimensional assessments of either existing programs or the conditions needed for optimal program design. We focus on a single ecosystem (tropical forest) in a single low income country (Madagascar) to achieve a uniquely complete analysis. Links to global structures involved in developing international payment for ecosystem services schemes (PES) ensure the results will be influential over a wider scale. Welfare impacts on the poor will be different under the major land-use changes which international payments are incentivizing. They also vary in their potential for producing global benefits.

Building resilience from the bottom up: the soil's role in regulating forest health in British Columbia, Canada. Reid, A. (*University of British Columbia, Canada; anyamartinareid@gmail.com*).

In British Columbia and the United States, forest pests kill approximately 25% of the annual allowable cut. Soil microbial and physiochemical properties can regulate damaging insects and pathogens. For example, soil acidification creates conditions more favorable for *Phytophthora ramorum,* the fungal pathogen that causes sudden oak death, and saprotrophic fungi can directly compete with the pathogenic root disease *Armillaria*. This common agricultural concept is gaining recognition in forest health research. The objective of this study was to determine soil properties that influence patterns of forest health in six long-term soil productivity (LTSP) sites established 15 to 20 years ago. Forest health was quantified by visual ground surveys, near infrared aerial imagery, and hemi-view photos. Pyrosequencing of the soil microbial community and standard physiochemical measurements also took place. Conventional and whole tree harvesting increased the abundance of soil pathogenic fungi by 45% and 47%, respectively. Whole tree harvesting created a 7% increase in poor or moribund trees compared to conventional harvesting. The abundance of soil pathogenic fungi is positively correlated to the number of poor or moribund trees (r=0.62). Further results linking forest health and soil properties pertinent to forest management policy and practices will be presented and discussed.

Insect plant relationships and the role of insects in mangrove conservation. Remadevi, O.K., Chatterjee, D., Mangala, N. (*Institute of Wood Science And Technology, India; okremadevi@gmail.com; yuv.jyoti@gmail.com; mangala_n2000@rediffmail.com*).

Mangroves in the west coast of India are fast being deleting due to manifold reasons, both natural and anthropogenic. Studies were conducted to investigate the insect-plant relationships and the role played by them in mangrove health and conservation. The interactions of insects with the mangroves as defoliators, woodborers, fruit feeders, parasites, predators, and pollinators were studied. A total of 625 species of insects belonging to 252 families of 15 orders were documented, and 282 insects could be identified up to genus/species level. Coleoptera, Diptera, Hemiptera, Hymenoptera, and Lepidoptera constituted the major groups in the collection. A total of 141 species of herbivorous insects were documented from the study. The leaf damage inflicted by different folivorous insects in three major mangrove species, namely *Avicennia officinalis, Rhizophora mucronata* and *Sonneratia alba,* was assessed using digital leaf area analysis, and it was found to vary from 0.5% to 16.11%. Diversity of flower-visiting insects and their visitation dynamics in six mangrove species, *Rhizophora mucronata, Avicennia officinalis, A.marina, A.alba, Sonneratia caseolaris* and *S. alba*, were studied in detail for documentation of major pollinators and their role in fruit setting. This study highlighted some of the most fascinating relationships of insects and plants in the mangrove ecosystem.

Relevance of LIDAR canopy and relief indicators in the assessment of spatial distributions of soil water resources under forest stands. Ridremont, F. (*University of Liège Gembloux-Agro-Bio Tech Belgium; francois.ridremont@ulg.ac.be*).

Water resources constitute one of the most decisive factors of the adaptation of forest ecosystems facing climate changes. The assessment of soil water resources should then lead to better determine forest sites vulnerability to water stress and to provide appropriate management recommendations. This study aimed to evaluate the relevance of canopy and relief indicators in the assessment of spatial distributions of soil water resources under forest stands (Belgium Ardenne Ecoregion, Houille watershed). The estimation of spatial and profile distributions of water resources were based on multi-year monitoring of real time soil moisture content (subsurface (15 cm) and profile (≤ 70 cm)) using TDR technology on 32 local sites. Additional laboratory analyses were conducted to determine soil properties influencing soil water content. The identification of canopy and terrain attributes able to explain the spatial distribution of soil moisture was derived from a LIDAR dataset and forest inventory. It is expected that the results could lead to the development of operational tools to ensure the forest site has tree species adequate to increasing the resilience of the forest ecosystems to ecological drifts.

Relevance of pedotopographical indicators in the assessment of spatial distributions of soil depth and soil water resources under forest stands. Ridremont, F. (*University of Liège Gembloux-Agro-Bio Tech, Belgium; francois.ridremont@ulg.ac.be*).

Water resources constitute one of the most decisive factors of the adaptation of forest ecosystems facing climate change. The assessment of soil water resources should then lead to better determining the vulnerability of forest sites to water stress and to provide appropriate management recommendations. This study aimed to evaluate the relevance of pedotopographical indicators in the assessment of spatial distributions of soil depth and soil water-holding capacity under forest stands (Belgium Ardenne ecoregion). Two factors that directly impact soil water content, soil depth and stoniness, were investigated in contrasting topographic conditions by: *(i)* two traditional and destructive methods (32 soil pits and 160 holes with auger soil); and *(ii)* an electromagnetic and non-intrusive method (5 120 m of ground penetrating radar traces with 200 and 500 MHz antennas). Additional laboratory analyses were conducted to determine soil properties influencing soil water content. The identification of terrain attributes able to explain the distribution of soil depth, and therefore of soil water-holding capacity, was derived from Digital Elevation Model from LIDAR. It is expected that the results could lead to the development of operational tools to ensure there are adequate tree species for the forest site in order to increase resilience of forest ecosystems to ecological drifts.

Influences of meteorological variables on the diametric growth of *Araucaria angustifolia* (Bertol.) O. Kuntze in Southern Brazilian Highlands. Rodrigues, A.L., Sanquetta, C., Corte, A.D., Mognon, F., Barreto, T., Behling, A. (*Federal University of Paraná, Brazil; alourencorodrigues@gmail.com; carlos_sanquetta@hotmail.com; anapaulacorte@gmail.com; mognonf@gmail.com; tauanebiologia@gmail.com; alexandre.behling@yahoo.com.br*).

Araucaria angustifolia (Bertol.) O. Kuntze (Araucariaceae), popularly known as *Araucaria*, is a neotropical gymnosperm widely distributed in the Southern Brazilian highlands. This research evaluated the diametric growth of *Araucaria* based on observations from eight permanent sample plots inventoried during 14 years (2000–2013) and its relation to meteorological data. Results indicated that growth is favored by elevated temperatures in April and May, possibly due to the extension of the growth season. Relative humidity in August was positively correlated with growth as well, and may be attributed to the growth restart and demands for water availability. On the other hand, positive anomalies in January temperatures had an adverse effect on *Araucaria* diametric growth, indicating stress development in abnormally hot temperatures, since this month has been found to be the hottest in the year in accordance with the historical series. Based on the meteorological annual averages, it was noticed that the number of rainy days in the year has a positive effect on tree growth. Such results reinforce the dependence of *Araucaria angustifolia* on a humid (ombrophilous) climate with mild temperatures, raising concerns on the species behavior under global warming scenarios.

Ecophysiology of seedling banks of tree species in contrasting environments of tropical rainforests in the Columbian Chocó Bioregion. Rodríguez Santos, N., Melo Cruz, O., Villanueva, B. (*University of Tolima, Colombia; natha8902@hotmail.com; omelo@ut.edu.co; bsvillanuevat@ut.edu.co*).

This paper studies environmental characteristics of seedling banks of the species *Roucheria monsalveae*, *Vochysia ferruginea,* and *Cespedesia macrophylla* in contrasting light regimes in tropical rainforests of the Bajo Calima region in the Columbian Chocó Bioregion. Precipitation in this region exceeds 7 000 mm/year, which makes it one of the rainiest regions on earth and one of the richest in biodiversity. The trees are commercially used by the local community of African descent, which has affected natural tree populations and threatened the sustainability of the resource. The first species generates seedling banks in environments with a photosynthetically active radiation (PAR) of 20%, the second one grows under a canopy of a PAR of nearly 12%, and the third one regenerates in forest clearings with a radiation higher than 65%. The density of seedling banks amounted to 135, 28, and 253 seedlings/m^2, respectively. *R. monsalveae* establishes its seedling bank under the canopy of the seed tree. *V. ferruginea* establishes its seedling bank in an area around the seed tree that is 3.5 times larger than the canopy area. *C. macrophylla* establishes its seed bank in forest clearings independent of the distance to the seed tree. These results facilitate the development of strategies for the management of natural regeneration of the species with a view to resource recovery.

Forest vs. oil palm: the differences in plant water use. Röll, A., Hardanto, A., Furong, N., Hoelscher, D., Hanf, A. (*Tropical Silviculture and Forest Ecology, Germany; aroell@gwdg.de; ahardan@gwdg.de; nfurong@gwdg.de; dhoelsc@gwdg.de; ahanf@gwdg.de*), Junedi, H, Yanto, H.

Tropical rain forests are being converted to oil palm plantations at large scales. We asked how forests and oil palm plantations differ in water use for transpiration. We studied eight remnant forest plots, eight oil palm plantations (8–12 years old), and an age sequence of oil palm plantations ranging from 2 to 22 years in lowland Sumatra, Indonesia. In the forest, we used thermal dissipation probes (TDP) in the stems of 8 to10 trees per plot and also analyzed vertical profiles of sap flux density. In oil palm, TDP sensors were installed in the leaf petioles, typically on four petioles per palm and four palms per plot. A specific calibration for oil palm leaf petioles was established. The derived daily transpiration rates showed higher maxima and higher temporal

variability in rainforest than in oil palm. Oil palm transpiration increased 15-fold between 1 and 16 years of age and then leveled off in older plantations (up to 22 years). Thus, landscape-level variability in transpiration is introduced by the age-class structure of oil palm plantations.

Historic forest fires as influenced by climate, vegetation, and man in boreal Scandinavia. Rolstad, J., Storaunet, K., Blanck, Y. (*Norwegian Forest and Landscape Institute, Norway; jorund.rolstad@skogoglandskap.no; stk@skogoglandskap.no; ylb@skogoglandskap.no*).

Knowing the variability in historic fire regimes is pivotal to succeed in predicting what may happen in the future. By cross-dating 745 fire-scars in 378 remnant Scots pines, we delineated the spatial and temporal pattern of 253 forest fires during the past 700 years in a 74 km^2 section of Trillemarka Nature Reserve in south central Norway. Their size, numbers, and frequency were compared with historic climate proxies, vegetation maps, and written sources. We found a strong anthropogenic signal from 1625 onwards, revealed by a sudden increase in early-season fires and a shift towards more frequent and smaller fires. Summer temperature was a prime driver of the occurrence and size of late-season fires, but not early-season fires, which presumably were man-made. Pre-1625 fire rotation averaged 236 years, presumably reflecting a natural regime. Spruce forests burned less often (rotation 250–1000 years) than pine forests (150–300 years). Anthropogenic use of fire peaked during 1600–1700s (rotation 50 years) but ceased after 1800. The last 200 years have been almost fire free, mostly due to increased fire control, but possibly also due to an increasing dominance of spruce and an efficient removal of coarse woody debris. Possible future scenarios will be discussed.

Effectiveness of compensation for habitat loss at intensified forestry by creation of dead wood. Rudolphi, J., Ranius, T., Caruso, A., Mats, J. (*Swedish University of Agricultural Sciences, Sweden; jorgen.rudolphi@slu.se; thomas.ranius@slu.se; alexandro.caruso@slu.se; mats.jonsell@slu.se*), Artti, J. (*Finnish Forest Research Institute, Finland; artti.juutinen@metla.fi*), Thor, G. (*Swedish University of Agricultural Sciences, Sweden; goran.thor@slu.se*).

Negative consequences of human activities for biodiversity may be mitigated by compensation measures. The interest in applying compensation measures is generally increasing, although rarely applied in forestry. Many boreal forests are managed by clear felling for timber and pulp production. There is an increasing interest in intensifying forestry by also harvesting slash and stumps for biofuel. We evaluated the efficiency of combining intensified forestry production with compensation measures, by estimating the net revenue from slash and stump harvest, the cost of high stump creation, and simulating habitat availability for 680 bark- and wood-living species under different scenarios of biofuel harvest and compensation. We show that harvest of slash and stumps has a clear negative effect on the habitat amount available for many species, especially fungi and beetles. Combining slash harvesting with creation of high stumps results in an economic surplus and provides significantly more habitat in comparison with no slash harvesting and no high stump creation. When undertaking stump harvesting it is currently impossible to achieve such positive effects. Our analyses show that compensation can be a useful tool when both economic and biodiversity goals must be achieved in forestry, but under certain circumstances it is a better alternative to avoid the activity that causes the negative effects.

Drought-induced canopy collapse triggers increased fuel loadings: implications for fire behaviour in a Mediterranean-type eucalyptus forest. Ruthrof, K., Fontaine, J., Hardy, G (*Murdoch University, Australia; K.Ruthrof@murdoch.edu.au; J.Fontaine@murdoch.edu.au; g.hardy@murdoch.edu.au*), Matusick, G. (*The Nature Conservancy, USA; gmatusick@tnc.org*).

Drought and heat-induced forest dieback have recently been reported from a wide range of forest types globally. Flow-on effects of such dieback events and their interaction with subsequent processes is receiving increasing interest. One key impact may be elevated fine fuel loads, which drive increased intensity and severity of fire. In order to determine changes in the fuel complexes following a widespread, drought-induced canopy dieback event in the Northern Jarrah Forest (NJF), southwestern Australia, we quantified surface fine fuel loading in severely-affected and minimally-affected forest areas. Sixteen months following the dieback event, severely affected plots had significantly higher fuel loadings (1hr fuels) than areas minimally affected by the dieback event. Total fuels were greater in severely affected areas. These are expected to increase as trees fall. This study has added to the work describing the impact of drought-induced canopy dieback events by reporting changes in fuel complexes. With climate projections for many regions of the world, such as those for southwestern Australia, suggestive of increasing aridity and temperatures, it is critical that we increase our understanding of the effects of, and responses to, drought-induced canopy dieback events in forest ecosystems.

Distribution of woodland key habitats in Norwegian landscapes. Sætersdal, M., Gjerde, I., Heegard, E., Nilsen, J., Schei, F. (*Norwegian Forest and Landscape Institute, Norway; sem@skogoglandskap.no; gji@skogoglandskap.no; ehe@skogoglandskap.no; jan-erik.nilsen@skogoglandskap.no; hof@skogoglandskap.no*).

The purpose of this study was to investigate the spatial distribution of woodland key habitats in Norway. Woodland key habitats are small stands or parts of stands that contain important habitats for biodiversity. They are mapped in connection with forest planning procedures. By utilizing such maps from 10 municipalities in Norway, we asked the question as to whether there are parts of the forest landscapes that have consistently low/high densities of woodland key habitats compared to the surveyed landscape as a whole, and therefore are well suited/unsuited for timber harvesting. The analyses included kernel density estimation of three variables: altitude, distance to road, and slope. We found that woodland key habitats are (1) highly overrepresented at lower altitude; (2) slightly overrepresented at long distances from road; and (3) highly overrepresented in steep terrain. We argue that the distribution of woodland key habitats at landscape scales in Norway reflects patterns of productivity combined with patterns of historical logging. Furthermore we argue that harvesting in steep terrain, especially at low altitudes, may come at a high price, not only economically but also for biodiversity.

The influence of forest tree mixture on the potential of carbon storage in Hyrcanian forest. Salehi, M., Zahedi Amiri, G. (*University of Tehran, Iran; m.salehi89@ut.ac.ir; ghavamza@ut.ac.ir*).

Climate change is the most important environmental challenge in 21th century. Regarding the potential of carbon sequestration in soil and tree biomass, forest stands provide the main sink for atmospheric carbon dioxide. On the basis of forest potential for storing atmospheric carbon, we attempted to investigate the potential for carbon storage at the Hyrcanian Forests in Iran. The study was carried out in the Golband and Kheyroud forest districts north of Iran. The characters determined for each district were growing stock and percentage of species composition. Evaluations for average weight per ton of carbon per hectare were calculated for each tree in different forest stands. Then, based on results of the research in Iran as well as global investigation, the relationship between specific gravity and volume of each tree was studied to estimate tree biomass to calculate the carbon storage. Namkhaneh districts in the Kheyroud Forest showed the highest carbon storage (117 ton/ha) and biomass (240 ton/ha). The lowest tree biomass and carbon storage (105.5 ton/ha) were indicated in Lalis district in Golband Forest. This research showed that tree mixture and species diversity are the most important factors to be evaluated for carbon storage potential.

Dynamic forest of tree species in a fragment of Mata Atlantica rainforest. Sampaio, R., Martins, L., Engel, V.L., Nehemy, M., Rodrigues, J. (*São Paulo State University, Brazil; ritacamilasampaio@gmail.com; leonardoamartins@gmail.com; veralex@fca.unesp.br; mfnehemy@hotmail.com; rodriguesflorestal@gmail.com*).

Understanding forest fragment's demeanor, behavior, and variation is a challenge to management. The aim of this research was to investigate the dynamics of a tree community of a rainforest remnant and comprehend the trajectory of fragments in a eucalyptus landscape. The survey of woody trees was conducted in 2007 and 2013 in a fragment in areas that are flooded and not flooded in plots of 10 m x10 m, totaling 1 hectare. All trees with a diameter greater than or equal to 5 cm at breast height quantified. The samples that did not fit the inclusion criterion and were not previously identified in 2007, were evaluated and marked in 2013. The result showed that a high species richness exists. Moreover, it is believed that by increasing the sampling area, the richness will grow to complete stabilization. The survey conducted in two periods showed no difference in the richness and diversity of species. The recruitment of new individuals resulted in increased basal area. Overall, there was higher recruitment than mortality. This result demonstrated that there is a positive balance in the forest, even though at the landscape, the impact is not large enough to cause transformation in the species composition.

Weather radar: an efficient tool for forest fire detection. Saraiva, E., Batista, A., Soares, R., Tetto, A. (*Federal University of Paraná, Brazil; ernandessaraiva@gmail.com; batistaufpr@gmail.com; rvsoares@ufpr.br; tetto@ufpr.br*), Gomes, A. (*São Paulo State University, Brazil; ana@ipmet.unesp.br*).

The efficiency on forest fire control is directly related to the quickness on the event detection and localization, which significantly can minimize the potential of damages. The current technology used in weather radars has opened new venues for research, making it possible to detect small signals. The objective of this research was to use the capacity of weather radar, configured to execute tasks of high sensitivity, to monitor and detect the smoke produced by sugar cane burnings and, by similarity, forest fires. An experimental model was developed and applied to the S-band weather radar operated by the Meteorological Research Institute–UNESP, located in State of São Paulo, Brazil. All the monitored burnings were efficiently detected at time intervals varying from 2 to 9 minutes, with an average of 4.67 minutes, significantly reducing the response time of 15 minutes considered optimal for conventional detection systems. The methodology used in this study can add significant value to the information in the forest fire suppression decision-making. The results showed the efficiency of weather radar to detect smoke. Therefore, weather radars systems could be used during the dry periods when they are mostly idle, for monitoring agriculture burnings and to detect forest fires.

Characterization of fine fuels in grass-woody steppe in Paraná State, Brazil. Seger, C.D., Batista, A., Tetto, A., Soares, R., Batista, D.B. (*Federal University of Paraná, Brazil; celsoseger@terra.com.br; batistaufpr@ufpr.br; tetto@ufpr.br; rvsoares@ufpr.br; dbiondi@ufpr.br*).

The Grassland Woody Steppe is one of the phytogeographic regions of Paraná State, covering an area of approximately 20 000 km^2. Comprised mainly of fine material, it presents a high fire danger potential, especially during the winter and early spring when the vegetation is killed by frost incidence, favoring the occurrence and spread of wildland fires. Data used in the research were collected from 35 sampling plots systematically distributed over an area of 25 hectares. Fine fuels were collected in the fall, winter, spring, and summer seasons over a period of 1 year. The average fine fuel load observed was 10 985 ton/ha, a value that is within the range reported in the literature for grassland vegetation. Three classes of fuels were considered in the analysis: live, dead, and miscellaneous. Along the four seasons of the year, the percentage of dead fuels remained stable while the living fuels and miscellaneous differed significantly. The moisture content in the three fuel classes showed little variation for the live fuels, while for the other classes, statistical variations were detected. These research results will contribute to the knowledge of fuels characteristics in the Steppe region on Paraná State and could contribute to fire control actions in that vegetation type.

Evaluation of soil anti-erodibility *Eucaltptus grandis* forest land. Sheng, K., Li, Z., Zhang, W., Niu, D., Guo, X., Liu, S. (*Jiangxi Agricultural University, China; skyjxau@163.com; lizhi876@163.com; zwyjxau@163.com; ndk2157@163.com; gxmjxau@163.com; liushun89@163.com*).

Soil anti-erodibility is one of the important parameters for evaluating the ability of soil resistance to soil erosion, and based on the comprehensive investigation on soil physical and chemical properties to incorporate them into a bioindicator. By using principal component analysis, all the 16 anti-erodibility indices could be optimized to seven indices which were water-stable aggregates at size >0.5 mm and >0.25 mm, destructive rate of aggregates at size >0.25 mm, coefficient of dispersion, degree of aggregation, viscous grain powder at size 0.05 mm, and viscous grain at size <0.001 mm. Changing laws of soil anti-erodibility of different ages of *Eucalyptus grandis* are discussed and the result showed that soil anti-erodibility indexes were: annual>2-years-old>Bud annual of 4-year-old >bare land. Using soil erodibility index as the dependent variable, soil erodibility model equation in the rare earth mining area are: $y=0.309x^1 + 0.038x^2 - 0.161x^3 - 0.643x^4 + 0.491x^5 - 0.0328x^6 + 0.129x^7 + 41.637$. The equation derived factors significantly related and the model fits well. The results can provide theory basis for improving the index system of soil.

Carbon and nitrogen storage in monoculture and mixed plantation stands of nitrogen-fixing tree species in subtropical China. Shi, Z., Luo, D., Cheng, R. (*Chinese Academy of Forestry, China; shizm@caf.ac.cn; luoda2010@163.com; chengrm@caf.ac.cn*).

Three young plantation stands (a monoculture *Erythrophleum fordii*, a monoculture *Pinus massoniana*, and a mixed stand of the two species) in subtropical China were selected to assess the potential of carbon and nitrogen sequestration. The results showed that the total carbon storage of the mixed plantation stand was 137.75 Mg/ha, higher than that of monoculture stands of *E. fordii* (134.07 Mg/ha) and *P. massoniana* (131.10 Mg/ha). Nitrogen storage ranked in order of *E. fordii* (10.19 Mg/ha), the mixed plantation (8.68 Mg/ha), and *P. massoniana* stands (7.01 Mg/ha). The spatial distribution of carbon and nitrogen were identical across the plantation stands, with the majority found in the 0~100 cm soil (occupied 81.49% and 96.91% of the total, respectively), followed by aboveground biomass represented by the trees (17.52% and 2.69%, respectively), and then understory and litterfall (all less than 0.5%). The above/underground ratios of carbon and nitrogen suggested that these three plantation stands have a tremendous potential for carbon and nitrogen sequestration. The results also indicated that mixed plantation stands with a nitrogen-fixing species could provide a better silvicultural model for carbon and nitrogen sequestration in comparison to monoculture stands in this area.

Potential vegetation dynamics under climate change in a semi-arid ecosystem in the Western United States. Shrestha, R., Glenn, N., Flores, A. (*Boise State University, USA; rupeshshrestha@boisestate.edu; nancyglenn@boisestate.edu; lejoflores@boisestate.edu*).

Modeling the future composition of terrestrial ecosystems in response to coupled dynamics of climate change and disturbances such as fire relies heavily on model parameterization. Fine-scale field-based measurements can provide the necessary parameters for constraining models at a larger scale. But the time- and labor-intensive nature of field-based data collection leads to sparse sampling and significant spatial uncertainties in retrieved parameters. In this study we quantify fine-scale vegetation dynamics in the Reynolds Creek Experimental Watershed in southern Idaho, United States. We used locally downscaled climate projections to run a dynamic global vegetation model, the output of which was used to inform a state-and-transition model to assess the fine-scale vegetation dynamics under climate change scenarios. We also leverage field-measured vegetation data along with airborne LiDAR to initialize a process-based fire model to examine vegetation dynamics in response to stochastic fire events. The results will improve our understanding of fine-scale vegetation dynamics in a semi-arid ecosystem and will provide a basis for generating ensembles of spatially-explicit alternative scenarios to guide future land management decisions in this and similar regions.

Which factors can explain changes in the distribution range of *Mimusops andongensis* Hiern in Benin? Sinasson Sanni, K. (*University of Abomey-Calavi, Benin; sinasson.gisele@gmail.com*), Shackleton, C. (*Rhodes University, South Africa; c.shackleton@ru.ac.za*), Sinsin, B. (*University of Abomey-Calavi, Benin; bsinsin@gmail.com*).

Mimusops andongensis is a multipurpose species with the wood used for construction, to produce charcoal, and as firewood. Its bark, roots, and leaves are used for local healthcare needs, and fruits and bark for alimentary uses. It can be found in many African countries on different habitat types: gallery and riparian forests, forest-savannah transition zones, dense humid and semi-deciduous forests, savannah and fallows in last stages of succession. In Benin, the species can hardly be found in other natural habitats except semi-deciduous forest. Also, changes are occurring in climate and environment and may impact its distribution range. This research aims to understand specific factors which explain *M. andongensis* current distribution range and highlight factors which may impact the species ecological niche under shifts in environment. Data on the presence, morphology, and phenology of the species will be collected through forest inventory. Climatic data will be obtained from WorldClim database and soil data will be analyzed to describe the ecological characteristics of forests to be sampled. Data collection began in August 2012 and will be finalized in May 2014. Potential changes in the distribution range of *M. andongensis* will be discussed using scenarios under future climatic conditions.

Hydro-climatic variation and its interactions with landscape units in the Brazilian Pantanal, South America. Soares, M.T.S., Soriano, B.M.A., Crispim, S.A., Santos, S.A., Fernandes, F.A. (*EMBRAPA, Brazil; marcia.toffani@embrapa.br; balbina.soriano@embrapa.br; sandra.crispim@embrapa.br; sandra.santos@embrapa.br; fernando.fernandes@embrapa.br*), Wrege, M., Salis, S.M.

In the Brazilian Pantanal, one of the largest wetlands of the planet, the delicate relationship between the dynamics of water, vegetation cover, and antropic disturbance in livestock activity remains unclear. The present study aims to monitor climatic parameters and fluctuation of the water table in different landscape units, relating them with the biomass productivity of areas used for beef cattle management activity. The study is being conducted in the Nhecolândia sub-region, Pantanal, western Brazil. From March 2009 to July 2010, we monitored rainfall (mm) and the fluctuation of the water table in 10 monitoring wells distributed in the savannah woodland and open grasslands with predominance of native grasses and *Urochloa* pastures, established in place of the native forest. Productivity parameters in open grassland with predominance of *Mesosetum chaseae* were also evaluated. The natural vegetation cover interfered distinctly with the behavior of subsurface waters, whereas under forestry cover, the periods of groundwater responses to rainfall were higher. In native pasture, cumulative rainfall and groundwater level were related to increased soil cover by grasses. It is expected that the long-term monitoring of hydro and ecological relationships can generate key information to support programs for sustainable management of the cattle ranches in Pantanal wetlands.

Simulating the dependence of aspen net primary productivity on redistributed snow. Soderquist, B., Kavanagh, K. (*University of Idaho, USA; sode5734@vandals.uidaho.edu; katyk@uidaho.edu*), Seyfried, M., Winstral, A (*Agriculture Research Services, USA; mark.seyfried@ars.usda.gov; adam.winstral@ars.usda.gov*), Link, T. (*University of Idaho, USA; tlink@uidaho.edu*).

In the semi-arid mountainous regions across the western United States, the distribution of aspen (*Populus tremuloides*) is often directly related to heterogeneous soil moisture subsidies resulting from redistributed snow. With increasing temperatures, the amount and timing of snowmelt subsidies are changing, therefore future trends in aspen net primary productivity (NPP) remain

uncertain. With decades of climate and precipitation data across elevational and precipitation gradients, the Reynolds Creek Experimental Watershed (RCEW) in southwest Idaho provides a unique opportunity to study the relationship between aspen NPP and redistributed snow. NPP of three aspen stands was simulated at sites spanning elevational and precipitation gradients using a biogeochemical process model (Biome BGC) and precipitation data adjusted to account for drifting snow. Simulations coupled with soil moisture data, diurnal branch water potential, and stomatal conductance observations detail drought onset and the use of soil moisture in the rooting zone. Simulations in drought years forced by adjusted precipitation data resulted in NPP values approximately 30% higher than simulations assuming a uniform precipitation layer. These results emphasize the importance of redistributed snow in heterogeneous landscapes along with the need to account for temporal shifts in water resource availability when assessing ecosystem vulnerability to climate change.

Estimation of uncertainty for carbon emission factors by major species in Korea. Son, Y., Kim, R., Pyo, J., Kim, S., Bae, J. (*Korea Forest Research Institute, Republic of Korea; treelove@forest.go.kr; rhkim@forest.go.kr; resilviculture@forest.go.kr; cfcc@forest.go.kr; forestory@forest.go.kr*).

Carbon emissions are an important factor in inventory systems relevant to carbon in forestry, yet relatively little is known about carbon emission and removal by species. Therefore, this study was conducted to estimate the carbon emission factors in Korea and to determine uncertainty. In this study, the major species included were three species of softwoods and two species of hardwoods. To evaluate differences of the emission factor among the species, analysis of variance and duncan's multiple range test were used. Results showed that basic wood density ranged from 0.408 to 0.721, and the average of basic wood density was 0.532 g/cm^3 (the average uncertainty of 5.6%) Biomass expansion factors range from 1.335 to 1.742 and the average was 1.522 (the average uncertainty of 21.5%). Root-to-shoot ratio range from 0.258 to 0.387 and the average of root-to-shoot ratio was 0.305 (the average uncertainty of 31.2%). The results of this study on the emission factor and uncertainty of the different major species are very significant in providing accurate information for estimating the inventory system of most forests in the Republic of Korea.

Adaptive forest management: The key for forest adaptation to climate change? Spathelf, P. (*Eberswalde University for Sustainable Dvelopment (HNEE), Germany; Peter.Spathelf@hnee.de*), Bolte, H. (*Thünen Institute of Forest Ecosystems, Germany; andreas.bolte@ti.bund.de*).

Climate change is likely to increase the vulnerability of forests in Central Europe. Adaptive forest management can help forest ecosystems to adapt to these new conditions in order to achieve management goals, maintain desired forest ecosystem services, and reduce the risks of forest degradation. Forest adaptation may occur at the population level via long-term evolutionary processes or by short-term phenotypic response of individual trees. An integrative adaptive management concept is proposed that combines (i) active adaptation measures such as forest conversion with (ii) elements of forest succession (passive adaptation). A strategic co-operation of relevant institutions at the international to local level is indispensable to implement scientifically sound adaptation concepts at the stand level. Constraints are first seen in the desire to use only locally adapted tree populations by natural regeneration, which is hampering the implementation of adapted rear-edge populations via planting. Secondly, late-successional species are favored in predominating close-to-nature silviculture systems in Central Europe, which limits the possibility for early-successional drought-stress tolerant tree species to develop more resilient forests.

The spatial extent of peatland as a response to climatic and topographic factors. Stokland, J. (*The Norwegian Forest and Landscape Institute, Norway; jogeir.stokland@skogoglandskap.no*).

Open and forested peatlands are key landscape elements in boreal and mountain regions where they have accumulated peat and acted as carbon sinks for millennia. Peatlands have expanded laterally, and their total area has grown since the last glaciation. This study modeled and cross-validated the spatial extent of peatland (minimum 40 cm peat depth) based on 15 000 National Forest Inventory plots in Norway. This is a mountainous country spanning from the temperate zone in the south, through the boreal zone, to arctic-alpine zones in the north and at high altitudes. The area proportion of peatland increased from below 5% in the temperate zone to above 20% in the north boreal zone and dropped again in the alpine zone. Summer temperature was most important for peat formation followed by terrain slope, whereas precipitation was significant but less important. Highest peatland frequency (ca. 60%) occurred in flat terrain from the mid boreal to the low alpine zone. The combination of summer temperature and topography facilitated peatland occurrence in increasingly steeper terrain in cooler climates. The study will discuss expected changes in peatland distribution and carbon accumulation rates under climate change scenarios based on the quantitative relationships in the model.

Temperature and UV-B radiation affect bud phenology in *Populus tremula*. Strømme, C., Nybakken, L. (*Norwegian University of Life Sciences, Norway; christian.stromme@umb.no; line.nybakken@umb.no*).

At high latitudes, tree species commonly synchronize phenological shifts to change of seasons. Even though appropriate timing is dependent on environmental cues such as temperature and light regimes, little is known of possible climate change effects on tree performance and survival. We have investigated multifactor climate change effects on males and females of the dioecious Eurasian aspen (*Populus tremula*) through outdoor experiments in eastern Finland (established 2012) and central Norway (established 2013). Autumnal bud set and spring bud burst was be recorded in both studies. In Finland, these phenological shifts were followed in response to combinations of simulated temperature (infra-red heaters) and UV-B enhancement (UV-B tubes). In Norway, we established plots along an altitudinal gradient in a valley side. In both studies we found that increased temperature (simulated or natural along gradient) extends the growing season, resulting in delayed bud formation. Males were more responsive to temperature. In Finland, UV-B radiation was found to have an opposite effect, which was stronger in male plants. In the same study, temperature had a positive effect on bud burst in spring, while UV-B had an additional positive effect on males. Further results from autumn 2013 and spring 2014 will be included.

Floral biodiversity with special emphasis on forest dieback in Dotolugala, Knuckles Forest Range, Sri Lanka.
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The present study describes the comparative accounts of diversity, dominance of tree species, and forest dieback with altitudinal variation and climatic condition of the forest. In this study, a stratified random sampling method was used for field sampling to analyze the importance value index, alpha, beta, gamma diversity indices, and to identify the status of dieback. Collectively, 75 plant species belonging to 49 genera and 30 families were recorded. They represented 42.6% (32 species) of endemism. In dry submontane forest, the highest IVI index was recorded for *Syzygium spathulatum* Thw. While in dry montane forest, the highest IVI index was recorded for *Calophyllum cuneifolium* Thw. Four species, *Semicarpus nigro-viridis, Symplocos cochinchinensis*, *Symplocos moore,* and *psychotria* spp., were represented in all the vegetation types. In general, observations of forest dieback were mainly concentrated on the wet face of the submontane forest. Clear observations were made on the invasion of dieback areas by *Srobilanthus* sp. which hindered the natural regeneration of local species. Closely related alpha and beta diversity indices in different ecosystems revealed the equal importance of the conservation application.

Responses of vegetation activity and water balance to changing climates in a sub-alpine large-scale watershed of southeast Tibetan plateau.
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The subalpine natural and regenerated forests in West Sichuan Province of China became susceptive to climate change because warming resulted in earlier snow melting, thus accelerating the water loss in spring and decreasing growing season water availability. Based on trend analysis of normalized difference vegetation index (NDVI), we found the increased vegetation activity was due mainly to a warming trend in the subalpine region. In this study, the coupled water-carbon modeling (WASSSI-C) that has been used for ecohydrology process simulation, takes into account not only hydrological processes but also vegetation dynamics, thus examining the vegetation and water relationship in the large scale watershed. In general, the results indicated that low soil water availability in spring time has become the main constrain of subalpine forest green up and has resulted in a browning trend in most forests. However, the alpine meadow and shrub land showed greening trends that were attributed to the increasing temperature. It was concluded that warming itself and warming-resulted improvement of vegetation activity reduced annul catchment water yield. Compared with that of the regenerated forests, the natural forest-dominated watershed showed a higher runoff rate. In general, our study illuminated how the forest restoration practice affects catchment water balance under a context of changing climate.

Spatial distribution and demographic structure of the critically endangered Dipterocarpaceae in fragmented habitat in Malaysia.
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Endangered tree species are often characterized by small population sizes, limited geographic distribution, and specific habitat requirements. Many of them suffered reductions in their population sizes due to fragmentation which results in loss in genetic variation within populations. Five tree species from Dipterocarpaceae, i.e., *Dipterocarpus semivestitus*, *Vatica flavida*, *Hopea apiculata*, *Shorea hemsleyana* and *Shorea macrantha*, have been reported to have restricted distribution in the freshwater swamp forest in Perak, Malaysia. Much of the area has been developed into urban settlements leaving small fragments of isolated forests in the area. The objectives of this study are to evaluate the spatial distribution of the species and to describe how the demographic structure of the species differs between populations. All trees within the study site were mapped using a Geographic Information System (GIS). The diameter at breast height (DBH) and tree classes of all trees were recorded. The number of trees ranged from 11 to 28 individuals per species. All trees were categorized under critically endangered based on IUCN. There is a significant difference in the means of DBH among all species ($P \leq 0.05$). The findings from this study may contribute to identifying species of special concerns and determining their susceptibility to future habitat fragmentation.

Estimating uncertainty for measurements of long-term climate impacts on forested ecosystems across the Continent.
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The National Ecological Observatory Network is responsible for making automated terrestrial observations at 60 different sites across the continent for the next 30 years. Data will highlight key physical, chemical, and climate forcing, as well as associated biotic responses (e.g., CO_2, H_2O, and energy exchanges). This will help inform how biodiversity and biogeochemistry in forested ecosystems are being driven by climate change. The sheer volume of data that will be generated far exceeds that of any other observatory network or agency (> 45 Tb/year from tens of thousands of remotely deployed sensors). We address the question of how to develop and implement an ecological observatory that can accommodate such a large volume of data while maintaining high quality. Here, we describe our approach to uncertainty for large scale measurements with specific examples that focus on quality control while leveraging cyber infrastructure tools. Novel approaches to uncertainty are utilized to advance the techniques that have been historically employed in other networks (DOE-ARM, AmeriFlux, USDA ARS, OK Mesonet) to new state-of-the-art functionality. Ultimately, NEON will build upon existing frameworks of standardized uncertainty characterization to define its own operational standards for continental scale data products.

A comparative study on evapotranspiration of the same trees in urban forests and individual tree using lysimeter method.
Teshirogi, J. (*Organization for Landscape and Urban Green Infrastructure, Japan; teshirogi@urbangreen.or.jp*).

Urban forestry plays a major role in the mitigation of hot urban environments. It is essential to accurately measure the amount of evapotranspiration and the source of its effect. However, because related measurements of the change in overall weight of a standard-sized planting using a weight scale involve a total weight of 1 ton or more, with the amount of change only fluctuating on the order of several hundred grams, such measurements are extremely difficult. The author has developed a new type of weight scale able to measure the amount of evapotranspiration from a large, full-sized tree (maximum weighing capacity 3 t)

and is using the large-sized scale to carry out long-term measurements comparing the evapotranspiration of individual trees and those located in forests. For this, three test pieces were prepared, two of which used *Zelkova serrata* with heights of 7 m, DBH of 50 cm, and weights of 1.8 t. One of these was planted as an individual tree specimen and the other within a forest, while the third test piece was intended only for measurement of evaporation from the soil. Measurements of the individual tree specimen in a temperate region of Japan during the summer season showed a maximum evapotranspiration of 44.6 kg within a 12-hour daytime period.

Forest planners' perception of future landscape trajectories: case study in a French forested mountainous region. Thierion, V., Luque, S., Parmentier, C., Marechal, D., Cordonnier, T. (*National Research Institute of Science and Technology for Environment and Agriculture, France; vincent.thierion@irstea.fr; sandra.luque@irstea.fr; clement.parmentier@irstea.fr; denis.marechal@irstea.fr; thomas.cordonnier@irstea.fr*).

Land use change has been one of the major influences on the French forests and wooded landscapes over the last 50 years, with the future likely to be affected through changes in climate and social and economic pressures. This poses forest planners and policy makers with a difficult task: how to make decisions that affect the future delivery of ecosystem services when faced by rapid land covers changes issues? One approach is to consider how a range of futures may unfold and stimulate interdisciplinary debate about land cover changes scenarios. This work, funded by EU FP7 OpenNess and ANR Systerra FORGECO project, experiments with this strategy in the Quatre Montagnes massif (French Alps) considered as a forested hot spo" of biodiversity for Europe and also part of a LTER (Long Term Ecological Research Network) worldwide network. This research employed Dinamica EGO software, a spatial-explicit simulation model, parameterized with knowledge on past landscape trajectories (work presented at IUFRO Landscape Ecology Conference in 2012), biophysical variables, and socio-economic conditions. Landscape trajectories revealed by this model confirm past trends including closure of pasture and farmland areas and increasing artificial areas in the valley. How will planners react to those incoming issues, especially for biodiversity conservation?

Impact of whole-tree harvesting on water quality and quantity from drained peatland forests in Finland. Ukonmaanaho, L. (*Finnish Forest Research Institute, Finland; liisa.ukonmaanaho@metla.fi*), Starr, M. (*University of Helsinki, Finland; mike.starr@helsinki.fi*), Kantola, M., Nieminen, M., Piispanen, J. (*Finnish Forest Research Institute Finland; marjatta.kantola@metla.fi; mika.nieminen@metla.fi; juha.piispanen@metla.fi*), Ari, L., Heikkinen, J., Pietilä, H., Perämäki, P., Loukola-Ruskeeniemi, K., Nieminen, T.

Increasing demand for production of bioenergy has led to an interest on the forest harvesting method which also removes logging residues (whole tree harvesting, WTH) in addition to stemwood. It is known that all forest management measures increase leaching of elements to the water courses, on the other hand. It is hypothesized that WTH might reduce nutrient leaching to waters because the amount of decomposable litter at the site essentially decreases. Our aim was to study the potential risk of harvesting drained peatland forests, both stem only (SOH) and WTH, on the mobilizing and leaching of elements to surface waters. The study has been carried out on eight drained peatland dominated catchments in Finland. Four of the catchments are underlined by felsic bedrock, four by black shale. In 2007 study plots were established. In 2009, two of the catchments were clear-cut using SOH and four using WTH including stump removal. The remaining two catchments were left unharvested. Ditch water samples have been collected since 2008 during the nonfrost season. Results showed there are differences in drainage water quality and quantity after the harvesting (both WTH and SOH) as well as between the bedrock types. The changes were strongest the first 2 years after harvesting.

Arthropods and flooding affect microbial communities in dead wood. Ulyshen, M. (*U.S. Forest Service, USA; mulyshen@hotmail.com*), Diehl, S. (*Mississippi State University, USA; sdiehl@cfr.msstate.edu*).

It is well established that the abundance, richness, composition, and arrival sequence of microbes in dead wood have important implications for decay rates, nitrogen fixation, and other key processes. How these organisms are influenced by arthropod activity remains largely unknown despite a great deal of interest in both communities. We, therefore, sought to determine how excluding termites (*Reticulitermes* spp.) and other arthropods from decaying logs would affect bacterial and fungal communities after 2 years in both seasonally flooded and unflooded forests in the southeastern United States. Culturing methods and terminal restriction fragment length polymorphism (T-RFLP) were used to compare the abundance, richness, and composition of bacterial and fungal communities between logs protected or unprotected from arthropods in both forest types. For both bacteria and fungi, community composition differed significantly between protected and unprotected logs and also between forest types. In addition, arthropods appeared to significantly increase the abundance and richness of bacteria. These findings indicate that arthropods strongly affect microbial communities in decaying wood and may, as a result, alter some of the key processes mentioned above.

Species and ecosystem diversity at Sacred Mountain National Park for habitat conservation in Marawi City, Philippines. Umali, A., Pampolina, N. (*University of the Philippines Los Baños, Philippines; arthurglennumali@yahoo.com; nelsonmanguiatpampolina@yahoo.com*).

Species and ecosystem diversity at Sacred Mountain National Park in Marawi Philippines was investigated in 2011 for its conservation and sustainable development. Vascular plants, vertebrate fauna, and macro fungi were systematically sampled along elevation gradients using quadrat sampling and trapping techniques. Soil, physiography, and microclimate were analyzed, and key informants interviewed. Ecological parameters were measured and statistically assessed to determine variations among ecotypes. The sacred mountain is a secondary growth forest with varying ecotypes along elevation gradients inhabiting some 167 plant species (25 endemic; 18 threatened); 69 faunal species (34 endemic; 6 threatened; 10 rare); and 24 fungal species. Standing volume (366 m^3/ha), tree density (DBH > 10 cm = 844 trees/ha), and total biomass (312.94 Mg/ha) were comparable to tropical logged forests. Biodiversity was high ($p < 0.05$) at middle elevations but lower in all other gradients and was correlated ($p < 0.05$) to environmental conditions, where sacredness of the mountain was outweighed by local socio-economic needs. Overall, participatory biodiversity conservation programs incorporating Islamic view are proposed to sustain habitat in SMNP.

Quantification of water related ecosystem services in watershed planning. Uygur, B., Serengil, Y. (*Istanbul University, Turkey; uygurb@istanbul.edu.tr; serengil@istanbul.edu.tr*).

Watershed systems are complex units (forests, urban, agriculture, rangeland) that provide many ecosystem services that can be classified into four groups: provisioning, regulating, cultural, and supporting such as biodiversity, water supplying, water protection, soil conservation, carbon sequestration, flood mitigation, and recreation. Besides this, throughout the years many factors like climate change and land use change have affected the ecosystem services. Land use change has especially been a threat for the ecosystem services. In other words, urbanization is a stressor in watersheds if the functionality of ecosystem services are disregarded during the landscape planning. So it's clear that ecosystem services should be in the plans for more flexibilit in urban landscapes. Defining the ecosystem services and quantifying them are the major steps to integrate these functions to the landscape plans. In this study, we aimed to define some ecosystem services in the West Mediterranean Basin and to quantify these by mapping to explain the differences between the years 1990–2000 and 2006 by using GIS. Based on these data, some implications are discussed for integrating the ecosystem services into the landscape plans.

Examining drivers of long-term trends in evapotranspiration in forested small catchments in the northeastern USA. Vadeboncoeur, M., Asbjornsen, H. (*University of New Hampshire, USA; matt.vad@unh.edu; heidi.asbjornsen@unh.edu*), Campbell, J. (*U.S. Forest Service, USA; jlcampbell@fs.fed.us*), Green, M. (*Plymouth State University, USA; mbgreen@plymouth.edu*).

A better understanding of the relationships between long-term trends in water balance and plant physiological responses to environmental drivers is necessary to better model future water stress in forests of temperate humid regions, which may be more vulnerable to drought than previously thought. Climate change scenarios project more frequent water limitation of forest productivity, in spite of modest increases in precipitation, due to less reliable precipitation timing and greater evaporative demand. We examined long-term trends and interannual variability hydrologic records 17–62 years in length from seven intensively studied, forested small watersheds from West Virginia to Maine and collected increment cores from each study site. The two longest records show significant declines of ~10% in ET over 50+ years, while shorter records show both positive and negative trends. Combining the meterological and hydrological records with annual-resolution chronologies of wood growth and C and O stable isotope ratios for the dominant tree species at each site will allow us to begin to distinguish among the various potential physical and biological drivers for these changes, which range from changes in growing season water availability, solar radiation, vapor pressure deficit, production, canopy structure, water use efficiency, atmospheric CO_2 concentration, among others.

Rainbow water and influence of terrestrial evapotranspiration on downwind rainfall patterns: emerging scientific evidence and complex geopolitics. van Noordwijk, M. (*World Agroforestry Centre (ICRAF), Indonesia; m.vannoordwijk@cgiar.org*), Gebrekirstos, A. (*ICRAF and University of Erlangen, Germany; a.gebrekirstos@cgiar.org*), Namirembe, S. (*ICRAF, Kenya; S.Namirembe@cgiar.org*), Minang, P. (*ICRAF and ASB Partnership for the Tropical Forest Margins, Kenya; a.minang@cgiar.org*), Mbow, C. (*ICRAF, Kenya; C.Mbow@cgiar.org*).

Rainbow water, atmospheric moisture derived from oceanic or terrestrial evaporation and/or transpiration, is becoming a tractable part of the hydrological cycle, preceding the rainfall, with green, blue, and grey water stages that have a longer history of quantification and policy development. While forest-climate discourse has become overly focused on carbon emissions and its macroclimatic impact, the mesoscale of hydroclimatic relations has received new impetus with availability of atmospheric moisture transport data and models. We will report on new efforts to derive isotope signals from tree rings in the Sahel that may indicate temporal shifts in oceanic versus terrestrial origins of the rainfall that was used in tree growth over the past 100 years. The geopolitical dimensions of the likely relations between East African land cover and West African rainfall are substantially different from current climate policies and discussions in the public arena.

Comparative analysis of different dead woods from old growth and managed Scots pine forests. Venugopal, P., Julkunen-Tiitto, R. (*University of Eastern Finland, Finland; venugopa@student.uef.fi; riitta.julkunen-tiitto@uef.fi*), Junninen, K. (*Metsähallitu, Natural Heritage Services, Finland; kaisa.junninen@uef.fi*), Kouki, J. (*University of Eastern Finland, Finland; jari.kouki@uef.fi*).

Boreal forests, particularly the natural old forests, are one of the most important global carbon stores. Dead wood biomass forms one of its main aboveground components. Decomposers play an important role in carbon dynamics in boreal forest. In addition to the amount of dead wood in the forest ecosystem, wood quality may be equally important to determine the success of any decomposer species. The study aims to evaluate the chemical and physical composition of different kinds of deadwoods obtained from old growth forest, including *Kelo* (very old standing dead pine) and managed Scots pine trees. The analysis was carried out using chromatography and scanning electron microscopy. The initial results indicate that the heartwood components differ considerably between the different types of deadwoods; particularly in the case of Kelo. The results show that qualitative variation in deadwood components warrants further study. It is hypothesized that substrate quality required for many highly specialized fungi living in the old growth forest may be related to the chemical and physical condition of the substrate. Such information is crucial for improving the restoration policies that are currently widely planned all over Europe.

Diversity, composition and distribution: how fire influences the shrubby understory both now and in the future. Vickers, H., Kasel, S., Duff, T., Nitschke, C. (*University of Melbourne, Australia; h.vickers2@student.unimelb.edu.au; skasel@unimelb.edu.au; tjduff@unimelb.edu.au; craign@unimelb.edu.au*).

This study examines the potential impact of past fire regimes and future climate change on the diversity, composition and distribution of woody understory species in Eucalypt dominated forests of south-eastern Australia. As a result of the 2009 Black Saturday Fires in Victoria, Australia, current policy recommends that 5% of public land be burnt each year in an effort to reduce fire hazard. An increase in fire occurrence is also predicted for this region under climate change. Consequently, the understories of forests in this region will experience changes in fire frequency and severity as a result of increased planned burns and wildfire. We hypothesized that such an alteration in fire regime will change the composition of shrubs at the stand level and their abundance and distribution at the landscape scale. Data on species composition and structure were collected from three ecosystems

(dry, damp, and wet eucalypt forests) that had experienced fire ranging from 5 to 74+ years ago. In addition, we sampled stands from the 2009 wildfire that had experienced different fire severities. This dataset was used to parameterize the LANDIS-II landscape disturbance and succession simulation model to investigate the response of understory species to climate driven changes in wildfire and planned burning regimes.

A matter of scale? predicting the distribution of shrub species at the local or landscape level using a national dataset. Vickers, H., Kasel, S., Duff, T., Nitschke, C. (*University of Melbourne, Australia; h.vickers2@student.unimelb.edu.au; skasel@unimelb.edu.au; tjduff@unimelb.edu.au; craign@unimelb.edu.au*).

As for many species the current climatic, edaphic, or structural requirements of a large number of temperate Australian shrub species is unknown. This lack of knowledge on the biophysical variables that characterize the current ranges of these species highlights an important gap that requires investigation if we are to understand the potential impacts of climate variability and change on their distribution. A national Australian dataset compiled from state herbarium and government records for 200 temperate shrub species was collated with species distributions maps and analyzed against bioclimatic variables. Field observations on stand structure, species abundance, site topography, and edaphic conditions collected from over 60 sites were combined with available broader soil, climatic, and topographic data to determine the local impacts of edaphic variables on a subset of the 200 species. This two-stage analysis was then used to model species distribution at local and landscape scales and against predicted changes in climate for the region. The study highlights the importance of considering edaphic, structural, and climatic conditions when modelling the distribution of understory species to climate variability and change.

Dynamics of physicochemical parameters during secondary succession of forest in the Cataniapo river basin, Amazonas State, Venezuela. Villa, P., Infante, J. (*Instituto Nacional de Investigaciones Agrícolas (INIA), Venezuela; villautana@gmail.com; jdinfanted@gmail.com*), Montilla, M. (*Ministry of Environment, Venezuela; mmontilla@gmail.com*).

The dynamics of secondary succession forest in Amazonas State is highly variable and depends largely on the types of disturbances. The aim of this research was to evaluate changes in the physicochemical parameters in different stages of succession. Soil samples were collected from 40 sites with different ages of succession and in primary forest at different depths: 0–10, 10–25, 25–45, 45–80, 80–100 cm. The evaluation was conducted in five successional stages: 3–4 years, 7–8 years, 11–12 years, 15–16 years, 19 to 20 years, and primary forest. Significant differences were observed in soil parameters between levels of depth and successional stages. The soil organic matter increases by forest succession, showing significant differences between the early stages in the first layer of soil (0–10 cm) which ranged from approximately 2.3% which was lower in contrast to advanced stages values of 3.09%, and 3.70% in primary forest. It is assumed that changes in the physicochemical parameters have a marked effect on plant succession.

Effects of wildfire on storm hydrographs. Wagenbrenner, J. (*Michigan Technological University, USA; jwwagenb@mtu.edu*), Robichaud, P. (*U.S. Forest Service, USA; probichaud@fs.fed.us*).

Wildfires can convert forests from areas of water storage and filtration to areas with nearly impervious bare slopes that funnel rainfall and sediment into overloaded channel networks. Some extreme changes in runoff rates have been documented, and increases in peak runoff rates of 2–3 orders of magnitude are not uncommon in the western United States. We compared hydrograph statistics for three catchments (117–227 ha) in eastern Arizona for the first three summers after a wildfire (2011–2013) to the responses from the same catchments in the unburned condition (1963–1983). In one catchment, the average post-fire time to peak runoff and storm duration was only 2% and 5% of the pre-fire values, respectively, while the peak flow rates increased by a factor of 16 after the fire. This resulted in increases in the slopes of the rising and receding limbs of the hydrographs, which were 170 and 440 times greater than the pre-fire slopes, respectively. Modeling post-fire runoff responses is challenging, and our analysis can be used for predicting post-fire responses in small catchments. These results can also be used to plan for post-fire flooding, including for emergency responses, protection of water quality, and assessment of potential ecosystem impacts.

Effects of tree species and mixture on soil C sequestration and greenhouse gases emissions in subtropical plantations. Wang, H., Liu, S. (*Chinese Academy of Forestry, China; whui1919@gmail.com; liusr@caf.ac.cn*).

Afforestation and reforestation are taking place at a large scale in southern China. There is a desperate need to carry out intensive research to build up a solid scientific knowledge for developing an updated management regime for multi-purpose plantation forestry. Indigenous broadleaf plantations are increasingly being developed as a prospective silvicultural approach for substituting coniferous plantations in subtropical China due to potential site degradation and the vulnerability of pest and disease damage. However, little knowledge is known about the effects of tree species conversion on stock and stability of soil organic carbon (SOC), and on soil-atmosphere greenhouse gases (GHGs) emissions. The relationships between biotic and abiotic factors and SOC processes were analyzed to assess the contribution of plant or soil microbes to SOC sequestration and GHGs emissions. The study revealed: (1) mixture is a better module to substitute conifer plantation, with higher SOC stock and lower GHGs emission than broadleaf monoculture; (2) future strategy needs to consider effects of tree species on chemical composition in addition to quantity of SOC; and (3) microbial-derived C compounds, rather than litter quality or a direct flux of C from recalcitrant litter materials to stable SOC pools.

Larch forest in northeastern China: carbon sink capacity and soil importance. Wang, W. (*Chinese Academy of Science, China; wangwenjie@iga.ac.cn*), Zu, Y. (*Northeast Forestry University, China; wwj225@nefu.edu.cn*), He, X. (*Chinese Academy of Sciences, China; hexingyuan@neigae.ac.cn*).

Larch is broadly distributed in the northern hemisphere, and it is the main afforestation species in NE China. Both biomass and eddy-covariance method manifested a strong C sink. The former showed 102~363 g/m^2/yr with an average 224 g/m^2/yr, while the latter showed 176~367 g/m^2/yr with an average 248 g/m^2/yr. A total of 159 chronosequence replicating sites manifested C

sequestration in surface soil (0–20 cm), but depletion was in subsoil (60–80 cm). Soil C sequestration could take 39% of total forest C sink. Larch forest C sequestration was at an expense of nutrient depletion, especially in subsoil. Linear regression analysis showed that N depletion was about 6 mg/kg/yr, and P depletion was about 3.5 mg/kg/yr. Multivariate analysis of variance showed that N and P was the most likely affected by larch growth, while K was seldom affected. Of the data, 53% showed marked changes in subsoil (40–60 cm), while this percentage decreased to 40% in all other layers. The most likely age-group for significant temporal changes was between 20–40 year and > 40 year age groups (35%), while this percentage decreased to 4% between 0–20 year and 20–40 year age groups. The long-term data in this study is important for carbon sink evaluation and highlighting the importance of soil for C capture and nutrient supply.

The reconstruction of the fire behaviors and its effects in the Melaleuca peat forest wildfire, Nakorn Sri Thamarat, Thailand. Wanthongchai, K., Kooha, P., Chairak, S. (*Kasetsart University, Thailand; fforksw@ku.ac.th; pkpforester74@gmail.com; popforest74@gmail.com*), Meesook, K. (*Department of National Park, Wildlife and Plant Conservation, Thailand; fforksw@hotmail.com*).

During the 2012 exceptional drought period in Southern Thailand (March to September), forest fires destroyed ca. 2100 ha of the Kuan Kreng peat forest, which consisted of pure stands of *Melaleuca cajuputi*. Unfortunately, fire behaviors and its effects on this forest type have never been investigated. In October 2012, therefore, five 10 m × 100 m burned plots and an adjacent five 10 m × 50 m unburned plots were set up to reconstruct fire behaviors using the fire forensic evident (i.e., fire scar, crown scorch height, and the fuels remained on site), and fire effects on *Melaleuca* mortality and growth rate of the survival trees were investigated. The result showed that fire consumed 75% of pre-burned fuel loads (54.9 t, ha). The reconstructed of the rate of fire spread, flame length, and fireline intensity were 12.5 m/min, 4.3 m, and 6 257.7 kW/m, respectively. The tree mortality was 18%, while sapling mortality reached about 74%. The correlation between mortality and fire behaviors descriptors were highly significant. The growth rate of trees that survived from burning was significantly lower (0.44 cm/yr) compared to the tree in the unburned site (0.68 cm/yr), reflecting the influence of burning on future forest structure and composition and hence the need for restoration.

Spatio-temporal distribution of rainfall at NTU Experimental Forest for climate change in central Taiwan. Wei, C. (*National Taiwan University Experimental Forest, China-Taipei; d87622005@ntu.edu.tw*).

Recent research suggests that hydro-climatic variables should be performed at the local scale rather than the global scale because they may exhibit different trends between different locations. This research aims to look at the spatio-temporal variation of rainfall at NTUEF area in central Taiwan for climate change. Eleven meteorological stations with more than 50 total years were analyzed with the intensity-duration-frequency (IDF) curve and 48 rainfall contours with different combinations of eight duration and six return periods. The result shows that: (1) Stations in higher elevation may satisfy the extreme value type 1 (EV1) distribution while those in lower elevation satisfy Log-Person Type III (LPT3) distribution. (2) The rainfall contours show that a clear rainfall center exists near Ali-Shan mountain area with longer duration and return period design storm. (3) The recent extreme rainfall events show similar rainfall patterns with 24 hr-200 yr design storm contours with the amount of rainfall increasing from north to south and east to west. (4) Annual rainfall of three stations show a slight increase while another three stations show significant decreases with 5% confidence. The results conclude that a difference exists for hydro-climatic variables for climate change at local scale, especially in mountainous forest area.

Long-term changes in climate, forest vegetation, and streamflow in the Priest River Experimental Forest, northern Idaho. Wei, L. (*University of Idaho, USA; liangwei@vandals.uidaho.edu*), Hudak, A. (*U.S. Forest Service, USA; ahudak@fs.fed.us*), Marshall, J., Link, T., Kavanagh, K. (*University of Idaho, USA; jdm@uidaho.edu; tlink@uidaho.edu; katyk@uidaho.edu*).

Changes in climate, forest vegetation, and streamflow were continuously monitored in the Priest River Experimental Forest (PREF) in northern Idaho. Streamflow was simulated using a process based hydrology model to interpret the causes for the historical increase of streamflow. PREF was established in 1911, and meteorology data has been recorded since 1911 and streamflow since 1939. Annual mean minimum daily temperature increased since the 1950s, and annual mean maximum daily temperature remained unchanged. Streamflow increased in the recorded period while annual precipitation remained unchanged. Forest inventories and remote sensing data (aero images, LiDAR, and satellite images) recorded the changes in the forest vegetation at PREF. We integrated the observations and modeling to find the causes of changes in the streamflow. The simultaneous heat and water (SHAW) model was run on the PREF. We parameterize the model with field measurements, especially the key physiology parameters for canopy conductance and forest transpiration. The model was validated with the observed streamflow and soil moisture.

Structural and compositional patterns in forest communities in the Intermountain West. Windmuller-Campione, M., Long, J. (*Utah State University, USA; marcella.campione@aggiemail.usu.edu; james.long@usu.edu*).

The interactions of changing disturbance regimes and climate change are predicted to influence forest structure, composition, and diversity, possibly creating novel forest ecosystems. The Intermountain West, USA is characterized by numerous mountain ranges, creating high mountain peaks and low intermountain basins. Multiple transects from low elevation woodlands to high elevation treelines were sampled. Sampling followed the guidelines of the U.S. Forest Service Forest Inventory and Analysis (FIA) program. Patterns of forest structure and diversity are associated with major environmental drivers. For example, as elevation increases there is a gradual increase in basal area of live and dead standing trees which peaks at approximately 2 900 m and rapidly declines. There is, also, an increase in live overstory species richness as slope increases from 15% to 25% with a decrease at greater slopes. A non-metric multidimensional scaling (NMS) ordination explains approximately 75% of variation in the data; elevation and understory vegetation cover were the two most strongly correlated variables. Increased understanding of current patterns of structure and diversity may aid in predicting future composition of novel forest communities of the Intermountain West.

Carbon flux of down woody materials in forests of the Eastern United States. Woodall, C. (*USDA Forest Service, USA; cwoodall@fs.fed.us*).

Across large-scales, the carbon (C) flux of down woody material (DWM) detrital pools has largely been simulated based on forest stand attributes (e.g., stand age and forest type). The annual change in forest DWM C stocks and other attributes (e.g., size changes) was assessed using a forest inventory in the eastern United States to provide an empirical assessment of strategic-scale DWM C flux. Using DWM inventory data from the USDA Forest Service's Forest Inventory and Analysis program, DWM C stocks were found to be relatively static across the study region but with differences among size classes serving as an inidcator of potential climate change effects. Given the complex dynamics of DWM C flux, early implementation of inventory re-measurement, and relatively low sample size, numerous future research directions are suggested.

Impacts of increasingly intensive removal of forest biomass on the biodiversity of leaf litter invertebrates. Work, T. (*Université de Québec à Montréal (UQAM), Canada; work.timothy@uqam.ca*).

Removal of forest biomass has been advocated as a renewable source of bioenergy and a mitigation strategy against climate change. Ironically, in the short term, intensive harvest of forest biomass including coarse and fine woody debris as well as stumps is likely to have significant impacts on biodiversity. We compared leaf litter invertebrates collected among jack pine stands which were: (1) stem-only harvested; (2) whole tree harvested (WTH); (3) WTH with additional removal of stumps; (4) WTH with stump removal and additional blading of organic material; and (5) uncut control stands. We identified more than 250 species (>35 000 individual arthropods) of ground beetles, rove beetles, and spiders. Stem-only harvesting and WTH and stump removal plots harbored greater total abundance than bladed sites, and assemblage composition varied as a function of intensity of biomass removal.

Changes in dimensions and zones occupied by native species of the southern rain forest in Brazil due to global climate change. Wrege, M., Sousa, V., Fritzsons, E., Soares, M.T.S., Aguiar, A. (*EMBRAPA, Brazil; marcos.wrege@embrapa.br; valderes.sousa@embrapa.br; elenice.fritzsons@embrapa.br; marcia.toffani@embrapa.br; ananda.aguiar@embrapa.br*).

The Araucaria Forest is located in southern region of Brazil and belongs to the Atlantic Forest biome. It is considered a hotspot of biodiversity and the zone has been given a high priority for conservation actions because this area has suffered rapid devastation. It has been continually exploited to give way to areas currently occupied by intensive agriculture of annual crops. These crops reap much of a grain harvest in the country but less than 6% of its original forest cover remains. These remnants are very small and fragmented, and less than 8% are larger than 100 hectares. In this work, studies were conducted to verify changes of dimensions and locations in the niches of the main species of this forest. This includes *Araucaria angustifolia*, *Mimosa scabrella,* and *Illex paraguaiensis*, using ecological niche modeling, verifying the changes in their dimensions and displacements, consistent with the future projections made by IPCC. We observed a reduction of spaces occupied by Araucaria Forest and its shift to higher altitude areas where climate change will have a smaller effect, showing the populations vulnerability of forest species in this vegetation type. It is also adversely affected. This study's findings indicated populations were significantly fragmented and their numbers were reduced due to strong anthropic pressure on the main agricultural regions of the country.

Tree species, decay class, ecosite classification, and dead wood decomposition rates in the mixedwood boreal forest of Canada. Wu, L., Bergeron, C., Lee, S., Spence, J. (*University of Alberta, Canada; linhao1@ualberta.ca; cb1@ualberta.ca; seungil1@ualberta.ca; jspence@ualberta.ca*).

Dead wood is an important component of forest ecosystems, contributing to carbon storage and forest biodiversity. This research examines the effects of tree species, decay class, and ecosite classification on dead wood decomposition rates in the boreal forest of northern Alberta (Canada). Discs were cut from white spruce, trembling aspen, and balsam poplar trees felled live in different ecosites in 2002, and these same trees were resampled as dead wood in 2013. Differences in biomass per unit volume were taken to represent decomposition rate, and these differences were related to tree species and ecosite. Five decay classes have generally been used to describe the extent of decay and are thought to be strongly correlated with dead wood density. However we found a large variation in wood density within decay classes and within single pieces of coarse woody debris. Differences in decomposition rates were also observed among ecosites and in relation to canopy closure, shrub cover, and extent of contact with the ground. This study revealed that several factors influence the decomposition rate of dead wood and, thus, such variation is important for understanding carbon budgets in boreal forest.

Community characteristics and species diversity of *Castanopsis fargesii* community in Three Gorges Reservoir area in China. Xiao, W., Xiao, W. (*Chinese Academy of Forestry, China; chengrm@yeah.net; xiaowenf@caf.ac.cn*).

Three Gorges Reservoir area is located in the sub-tropical moist region of China. The total area is about 54 000 km^2, and evergreen broadleaf forest is the zonal vegetation type. *Castanopsis fargesii* forest is one of main vegetation types. The research on the community structure and species diversity of *Castanopsis fargesii* forest will have a long-term meaning for the biodiversity conservation in the area and the regional economic development. According to the data from 18 plots, the forest was divided into three community types. The vertical structure of all community types is obvious, it could be divided into tree layer, shrub layer, and herb layer. The trend of species richness index, diversity index of different layers in all community types is shrub layer>tree layer>herb layer. Due to the strong disturbance of human activities, the trend of these indices along the altitude gradient is not obvious. At the same time, environment pollution should not be overlooked. For example, acid rain has been found in this area and affected the forest.

Short-term impact of whole tree harvest at thinning on cation dynamics in a Japanese cedar forest ecosystem. Yamada, T., Hirai, K. (*Forestry and Forest Products Research Institute, Japan; yamadan@ffpri.affrc.go.jp; hirai@ffpri.affrc.go.jp*), Takenaka, C. (*Nagoya University, Japan; chisato@agr.nagoya-u.ac.jp*), Nishizono, T., Amano, T., Kodani, E., Shibata, M., Yagihashi, T. (*Forestry and Forest Products Research Institute, Japan; nishizo@ffpri.affrc.go.jp; chisho@ffpri.affrc.go.jp; kodani@ffpri.affrc.go.jp; shibarin@ffpri.affrc.go.jp; yagihasi@ffpri.affrc.go.jp*).

The change of nutrient dynamics in a forest ecosystem by utilization of forest biomass is becoming an increasingly important topic for forest management. The harvesting of biomass, not only stems but also branches and leaves, should have large impacts on forest soils and tree growth. To evaluate the short-term impact of whole tree harvest (WTH) on forest soils, we conducted a thinning with WTH and investigated the changes of the dynamics of exchangeable base cations (BC) by using ion-exchange resin in a Japanese cedar forest, northern Japan. Efflux of BC through the forest soil at 50 cm depth was affected more by WTH than stem only harvest (SOH) 2 years after the harvest. This result indicated that the harvest of branches and leaves brought the change of nutrient dynamics in the forested ecosystem and might suggest the importance of treatment of branches and leaves for sustainable forest management.

Evaluation of broad leaf tree diversity in artificial forests at the landscape level. Yamada, Y., Kosaka, S. (*Nagoya University, Japan; yozo@agr.nagoya-u.ac.jp; kosaka.sayumi@mbox.nagoya-u.ac.jp*).

The conservation of biodiversity in forests is important for preserving the various functions of forests, ranging from ecosystem functions to timber production. In Japan, this requires the sustainable management of artificial forests, focusing on the conservation of biodiversity, because 28% of the country is covered by artificial forest. One way to achieve this goal is to increase biodiversity at the landscape level by planning the optimal distribution of compartments containing broadleaf trees. It is difficult to determine the biodiversity of artificial forests at the landscape level, as few studies have examined methods to evaluate this. This is a major problem, especially for forest managers who must conserve biodiversity. Therefore, we developed a method to evaluate biodiversity in artificial forests at the landscape level that can be used by forest managers. This method first evaluated the diversity of broad leaf trees in subcompartments using several species diversity indices, and then examined diversity at the landscape level using network indices in a geographic information system (GIS).

Dynamic variation of the rainfall infiltration in the deep soil of the drifting sand in main desert lands of China. Yang, W., Dang, H. (*Chinese Academy of Forestry, China; hzdang@sina.com; hzdang@caf.ac.cn*).

Soil moisture, the key constraint in the arid ecosystem, has become the hotspot in arid-area research and eco-restoration. However, little quantitative data on the amount of deep soil infiltration water from rainfall are available. This study measured the amount of the rainfall infiltration below 150 cm with the YWB-01 deep soil leakage recorder in four sandy lands/deserts: Mu Us sandy land, Ulan Buh desert, Tengger desert, and Badain Jaran desert. The consecutive 2-year data showed: 1) The total infiltration water in Wushen Banner sandy land can reach 508.4 mm, 58.4% of the concurrent rainfall amount, and 23.8 mm and 13.9% in Dengkou desert, but no infiltration occurred in Alxa Left Banner and Alxa Right Banner. However, the stronger the precipitation, the more infiltration recharge occurred for shifting sandy land in arid and semi-arid areas; 2) The seasonal variation of the infiltration is nearly consistent with the rainfall in the areas with plentiful rainfall; and 3) For the one-time intensified rainfall, there is a peak value of leakage after 40–55 hours of the rainfall, during which, the infiltration rate increased rapidly before the peak and decreased slowly after. The infiltration course can last about 150 h.

A quantitative analysis of hydrological variability associated with afforestation of degraded croplands in South China. Yu, P., Wang, Y., Pan, S., Xiong, W., Xu, L. (*Chinese Academy of Forestry, China; yupt@caf.ac.cn; wangyh@caf.ac.cn; apeterpan@163.com; Xiongwe@163.com; xulih@caf.ac.cn*).

The Grain for Green Project is a country-wide ecological program in China since 2002, to promote the conversion of marginal agricultural land to forest. In order to understanding the influence of this afforestation, the Guansihe Hydrological (GSH) Model was used in the Guansihe basin, South China. The model simulation showed that runoff generation after conversion to forests was strongly dependent on whether the land was initially covered by dry croplands or paddy fields. The watershed runoff generated from a rainfall event showed very little change when dry croplands were converted to forest. However, the runoff would strongly decrease when paddy fields were converted to forest. As water barriers in croplands, the effect of terraces on runoff generation depends on rainfall magnitude and antecedent moisture in fields. In paddy fields, the combined effect of terracing and afforestation on total runoff and peak flow reduction under heavy rainfall exceeds 10% and 15%, respectively. These mean that there is a living threshold for terraces due to the mechanism of saturation excess runoff in this region. It was demonstrated that afforestation and terracing has the potential to mitigate flooding in southwestern China. However the level of impact is strongly dependent on watershed characteristics.

Determination of soil carbon sequestration by using humic content in pure and mixed stands of beech in Kheyroud Forest, Iran. Zahedi Amiri, G., Azizi, N., Salehi, M., Marvie Mohadjer, M., Shirvani, A. (*University of Tehran, Iran; ghavamza@ut.ac.ir; nabi.azizi@gmail.com; m.salehi89@ut.ac.ir; mohadjer@ut.ac.ir; shirvany@ut.ac.ir*).

This study was done in two pure and mixed stands of beech in Kheyroud Forest north of Iran to determine soil carbon sequestration by using humic content. For measuring carbon content in mineral horizons, 30 profiles were dug in each stand. In organic horizons, humic and fulvic acids and carbon sequestration were determined. Percentage of carbon in various horizons in both pure and the mixed stands showed significant differences, but there were no significant differences between two stands. Among all of the horizons in terms of humic and fulvic acids in both stands, there was a significant difference, but the percentage of acids did not show significant differences in two stands. In the three organic horizons, significant differences in carbon sequestration were seen between stands. There were no significant differences in the measured parameters between the two stands which can be explained because tree composition and litter quality in both stands were similar. Another factor that may be involved is topographical conditions of the sampling sites.

The species and functional diversity variation along secondary succession of tropical lowland rain forest on Hainan Island, China. Zang, R., Bu, W., Ding, Y. (*Chinese Academy of Forestry, China; zangrung@caf.ac.cn; bws2007@163.com; ydingcaf@gmail.com*).

Recently, we used functional traits and functional diversity to greatly improve our understanding about the ecological functioning and recovery of the secondary forest. In this study, we explored functional traits and diversity along a chronosequence of

secondary forest plots ranging from 18 to 60 years since abandonment after shifting cultivation on Hainan Island of south China. We included two old-growth forest plots for comparison. Our results showed that species richness and Shannon-Weaver index increased with the process of succession. Specific leaf area, leaf nitrogen content, leaf phosphorus content, and leaf total organic carbon content decreased and leaf dry matter content, wood density, and potential maximum height increased with succession. Leaf potassium content did not show significant change with succession, however. Functional richness, functional evenness, functional dispersion, and Rao's entropy index decreased first and then increased with the process of succession. Functional divergence peaked in the 60-year-old secondary forest. Functional traits and diversity (species and functional diversity) along succession were affected by different environmental factors. The key environmental factors driving functional traits and biodiversity in 18-, 30-, and 60-year-old secondary forest and old-growth forest were pH and soil organic matter, canopy openness, soil total potassium content, and available phosphorus content, soil phosphorus content, respectively.

Short-term variability of the spring and stream water chemical composition in catchment with different antropopressure (Carpathian, Southern Poland). Żelazny, M. (*Jagiellonian University, Poland; miroslaw.zelazny@uj.edu.pl*), Małek, S. (*University of Agriculture in Krakow, Poland; rlmalek@cyf-kr.edu.pl*), Astel, A. (*Pomeranian University, Poland; astel@apsl.edu.pl*), Joanna Paulina, S., Amanda, K. (*Jagiellonian University, Poland; joanna.siwek@uj.edu.pl; amanda.kosmowska@uj.edu.pl*).

Southern Poland used to be one of the most polluted regions in the world in the period 1970–1990. Trees began to die across the Skrzyczne Massif in the Silesian Beskid region in the 1990s due to air pollution and acid rain. Forest loss affected significant parts of the ridge area of the massif. This outcome also affected water content in the region and the chemistry of springs and small streams. Daily changes in water chemistry were investigated in near-surface soil layers in order to assess the effect of environmental pollution. The concentrations of main ions and biogenic compounds were analyzed. Other parts of southern Poland were analyzed for comparative purposes including the Carpathian Foothills and Tatra National Park, both areas much less affected by human activity.

The impact of forest vegetation change on water yield in the subalpine region of southwestern China. Zhang, Y., Liu, S. (*Chinese Academy of Forestry, China; zyd@caf.ac.cn; liusr@caf.ac.cn*).

Forest harvest increases annual water yield, which is a general conclusion from paired catchment experiments in forest hydrology. However, there have been many studies suggesting that harvesting subalpine forests decreased annual water yield in Yangtze River upper reaches. In this study, meta-analysis for compiling data from many former studies was used to analyze annual water yield changes resulting from changes in vegetation in Yangtze River upper reaches. Our results showed that old dark coniferous forests have a lower annual ET and a higher annual water yield compared with shrubs, naturally regenerated forests, and spruce plantations after harvests. Water yield increased rapidly in the first 3 years after the harvest of old growth forests and returned to the original level at the 6th year but then declined continuously to a relatively lower level over a long period that corresponded to the vegetation succession into the shrubs, secondary broad-leaved forests, mixed forests, or spruce plantations. The period with a relatively lower annual water yield could sustain more than a century. We recommend that paired catchment experiment should be carried out to provide effective decision support for forest restoration and management practices in the region.

Changes in carbon density for three old-growth forests on Changbai Mountain, Northeast China. Zhou, L. (*Chinese Academy Sciences, China; zhouli930@iae.ac.cn*).

The old-growth forests on Changbai Mountain have been well protected from human activities and provide a living laboratory for studying forest carbon sequestration under natural environmental conditions. We used data from permanent plots periodically measured in 1981 and 2010 to quantify carbon densities for Korean pine-broadleaf mixed forest, coniferous forest, and Erman's birch forest on Changbai Mountain. Carbon pools were divided into tree stems, leaves, branches, coarse woody debris, tree roots, and soil. Although the mixed forest experienced minor wind damage, every forest component except for coarse woody debris experienced increases in carbon density, and the total forest carbon density increased from 233 to 317 t C/ha. The coniferous forest was severely damaged by wind, so carbon content in trees decreased, but the total forest carbon density still increased from 298 to 327 t C/ha. The birch forest gained much carbon in trees but the soil carbon pool remained relatively stable, and its total carbon density increased from 226 to 281 t C/ha. The old-growth forest was more resilient to disturbance than previously thought. The positive increases in carbon for the three old-growth forests suggest that forest landscapes on Changbai Mountain are indeed carbon sinks.

Spatial heterogeneity of soil available nutrients in black willow plantation in Gonghe Basin, Qinghai-Tibet Plateau. Zhu, Y., Jia, Z. (*Chinese Academy of Forestry, China; zhuyajuan80@gmail.com*; *jiazq@caf.ac.cn*).

Spatial heterogeneity of soil nutrients is an important characteristic in semi-arid ecosystems. After the establishment of a shrub plantation, spatial distribution of soil nutrients may affect community structure and function. In this study, soil was collected at different locations of black willow plantation on an inter-dune in Gonghe Basin (e.g. windward outside, windward under, inside, leeward under and leeward outside shelterbelt) to measure organic matter, total and available nitrogen, phosphorus and potassium content. The results indicate organic matter or total potassium was similar at different locations. Total nitrogen accumulates at the surface (0–10 cm) at windward under shelterbelt. Total phosphorus accumulates at deeper depths (20–50 cm) at windward outside shelterbelt. Available nitrogen accumulates at windward under shelterbelt or inside shelterbelt at 0–5 cm depth; at windward outside shelterbelt at 5–10 cm depth; and at windward outside or under shelterbelt at 10–20 cm depth. Available phosphorus accumulates at windward outside shelterbelt and in surface soils (0–5 cm). Available potassium accumulates in surface soils (0–5 cm) inside or at leeward under shelterbelt. Therefore, spatial heterogeneity of soil nutrients was induced by wind in black willow plantation in alpine sandy land, especially for available nitrogen and phosphorus.

GENERAL POSTER SESSIONS

IUFRO Division 9: Forest Policy and Economics

Administration and management of state and non-state forests in Romania: one law, two perspectives. Abrudan, I. (*Transilvania University of Brasov, Romania; abrudan@unitbv.ro*).

The paper assesses the post-1990 legislation regarding the administration and management of state and non-state forests in Romania and its different provisions according to forest ownership status. After three forest restitution laws and several institutional reforms undertaken in the last two decades, the present forest legislation distinguishes between the administration and management of state and non-state forests, whilst sustainable forest management is the main principle in both cases. The differences are reflected by the institutional and organisational arrangements (state forest districts versus private forest districts), supervisory and inspection procedures, and fiscal/budgetary restrictions. Some of these differences have a positive impact on the development of the non-state forest sector, but other provisions represent an undue burden on the progress of forestry in Romania.

How ideas, interests, and institutions may block or further policy integration: an evaluation of the forest and agricultural sectors in Ghana. Arts, B. (*Wageningen University, Netherlands; bas.arts@wur.nl*), Sarpong, Y. (*Kwame Nkrumah University of Science and Technology, Ghana; amosarpong@gmail.com*).

"Integrated natural resource management" (INRM) is one of the new buzzwords in the field of use, management, and conservation of natural resources (NR). But INRM is not easily realized, because NR sectors and their policies and management are often organized along the lines of rather closed sectors—or pillars—in most countries around the world. This paper analyses attempts in Ghana to achieve integration at the policy level as well as in natural resource management on the ground. The focus is on the forest and agricultural sectors, which are the two main Ghanaian NR sectors (besides oil). Hence, the authors focus on policy integration both from a horizontal perspective (issue-specific sectors) and from a vertical perspective (policy and management levels). Various programs have been established in Ghana to integrate issues at different levels of forestry and agriculture. Five recent programs were chosen for consideration in this paper: the National Forest Plantation Development Programme (NFPDP), Community Forest Management Project (CFMP), National Resources and Environmental Governance Programme (NREG), Ghana Rural and Agricultural Finance Programme (RAFiP), and Northern Region Poverty Reduction Programme (NORPREP). Since the success (or lack thereof) of these initiatives remains to be seen, the authors will analyse and evaluate these programs in this paper.

Behind the scenes—revealing true volume of wood production and markets in a developing economy: Tanzania. Arvola, A., Kanninen, M. (*University of Helsinki, Finland; anne.arvola@helsinki.fi; markku.kanninen@helsinki.fi*).

International climate change discussions and negotiations, and the Rio +20 Conference, have given a clear signal of global need and willingness to move towards a green economy and green investments. On the other hand, official global statistics show that global wood consumption per capita is decreasing rapidly. The reality at the national level is very different from the global trend in countries with rapidly growing populations and economies, such as Tanzania. Official statistics often reveal only a part of an ongoing transformation process, in which trees grown are increasingly grown on farms and small woodlots to meet the market demands for construction and fuelwood. Tree farming is still a no-man's-land because neither forest authorities nor agricultural sector authorities have interest in taking the responsibility of tree farming. This paper builds a more comprehensive picture of Tanzania tree farming and its importance in national wood markets and of the challenges and barriers tree farmers face in the absence of a supportive environment. The analysis is based on data collected from existing national records, from interviews at both the national and the farmer level, and from the National Forest Resources Monitoring and Assessment project (NAFORMA).

Deforestation causes in the Huila department of Colombia—a jurisdictional REDD+ approach. Becerra, M. (*International Forestry Students Association, Colombia; cata007201@gmail.com*).

Currently in the Huila department of Colombia, about 10 000 ha of natural forests are lost annually, a situation that has spurred a variety of organizations to consider ways to effectively deal with deforestation processes. The Corporación Autonoma Regional del Alto Magdalena (*CAM*) and ONF-Andina, with support from the Corporación Autonoma del Rio Grande de la Magdalena (CORMAGDALENA) have led the way in identifying the main causes of deforestation and degradation in the Huila region. This is the first step towards development of a jurisdictional REDD system, which in the future would allow implementation of alternatives that would mitigate these processes and would contribute to the global effort to reduce deforestation in developing countries through a REDD + program. Surveys and interviews were conducted to determine potential agents of deforestation. Results obtained from the surveys and secondary information were revised. Subsequently a workshop was held in the city of Neiva to validate the preliminary results. A final list of direct and indirect causes of deforestation was drawn up. The workshop also served as a forum to raise community awareness about the ways drivers of deforestation influence operations in the department and in the hotspots identified. Of the major results, this paper highlights those related to the expansion of specific crops and the expansion of extensive cattle ranching activities in areas of difficult access.

Interrogating safeguards for Jurisdictional REDD+: a study of overseas jurisdictional REDD+ offsets in California's Global Warming Solutions Act. Blanchard, E., Vira, B. (*University of Cambridge, UK; blanchard.libby@gmail.com; bv101@cam.ac.uk*).

In 2006, the State of California (USA) passed into law Assembly Bill 32, requiring the reduction of statewide greenhouse gas (GHG) emissions to 1990 levels by 2020. California's cap-and-trade program took effect in 2012, and in 2013, the state made its final recommendations for the incorporation of international REDD+ offsets into its cap-and-trade program. California proposes buying carbon credits from international REDD+ projects in "Partner Jurisdictions" overseas to offset its emissions, which raises

particular social and biodiversity considerations. Proponents say that these "jurisdictional REDD+" credits will keep compliance costs of affected California industries within a workable range. However, critics argue that the offsets may not reduce total GHG emissions, and that offsetting may reinforce or worsen preexisting inequalities, despite proposed safeguards. This paper examines the environmental and social safeguards that have been proposed for these jurisdictional REDD+ offsets, how monitoring of these safeguards will be enforced, and how tradeoffs between socioeconomic and conservation goals are negotiated within jurisdictional REDD+ project design and implementation. The study identifies social, economic, and environmental risk factors that may jeopardize the sustainability of these ecosystem service-based agreements, and results discuss the broader policy implications of a jurisdictional REDD+ approach to other multilateral and subnational GHG reduction initiatives.

Maintaining forestry archives for the future. Bridle, O., Petrokofsky, G. (*University of Oxford, UK; oliver.bridle@bodleian.ox.ac.uk; gillian.petrokofsky@zoo.ox.ac.uk*).

The University of Oxford has a long history of providing information services for forestry. Although collections of forestry material at Oxford have moved several times, they still provide an important and often unique archive of forestry publications spanning more than a century. This poster highlights the recent work at the Radcliffe Science Library to catalogue the contents of the Forestry Research Programme (FRP) archive. The FRP was a long-term programme of the UK government's Department for International Development (DfID), which ended in 2006 with the archives from the project subsequently deposited at the library. The archive contains extensive documentation for projects and publications produced as part of the FRP, along with relevant administrative records. In 2012 work was undertaken to organise and catalogue these archives so that they can now be found through the publically available library catalogue (SOLO) and associated online finding aids. This example demonstrates the crucial role libraries continue to play in making data and publications from forestry projects accessible to future researchers, communities and policy-makers. In an increasingly digital information world, this project also shows the importance of preserving physical collections, which are often in danger of loss or dispersal.

Forest management in the long term: participatory scenario evidence from Slovakia. Brodrechtova, Y., Navrátil, R., Sedmák, R. Tuček, J. (*Technical University in Zvolen, Slovakia; brodrechtova@tuzvo.sk; navratilr@tuzvo.sk; sedmak@tuzvo.sk; tucek@tuzvo.sk*).

Forest management is being significantly challenged by competing demands for forest ecosystem goods and services as a result of changing environmental, economic, and social conditions. The search for answers to the question of future forest-related conditions and their consequences for forest management is complex, especially in countries like Slovakia that have undergone institutional upheaval in the last 20 years. By using scenarios, foresters can imagine various futures (e.g., in 25–30 yr). Thus, a qualitative participatory scenario process was conducted with regards to forest management practices in Slovakia. Two case study areas, Podpoľanie and Kysuce, were selected as representing current trends and tensions among forestry, environmental protection, and the timber industry in Europe. Building on previous research (theoretical and empirical analysis of structural and agent-based factors), the authors conducted participatory scenario-building workshops with 13 national and local stakeholders, structural analysis, and morphological analysis. This process resulted in the elaboration of three or four exploratory scenarios for each case area. Despite Slovakia's size, the preliminary results revealed notable diversity in future drivers (e.g., bioenergy market, population, non-wood ecosystem services, codes of conduct) and subsequently in scenarios for long-term forest management.

Kaldor-Hicksim improvement study on social welfare of families in state-owned forest areas under China's logging ban. Cao, Y., Liang, Y. (*Northeast Forest University, China; yc_liang@126.com; 3262526@qq.com*).

A ban on logging has been in effect in China for 10 years. The ban was renewed in 2011 after its initial success. The objective of this research is to evaluate the effects of this ban, with a focus on the primary implementation in northeast China and Inner Mongolia. The quantitative analysis method was used to evaluate the impacts based on data from 1997, 2005, and 2009. Results indicate that the ecological effect is significant, with the value of forest carbon sequestration being twice that of the corresponding inputs of the project. Results also show that social welfare has been greatly improved even though the welfare of those families with children in school and elderly people is relatively lower than that of other groups. These families have higher monetary marginal utility. An improvement in their welfare would offset or even more than offset the cost. If a Kaldor-Hicksim improvement were made, it would enhance the overall welfare of the state-owned forest area. Substantial suggestions are also given in this paper.

Analyzing direct and underlying drivers of deforestation and forest degradation for REDD+ in Cameroon: methodology development and pilot test. Carodenuto, S., Merger, E. (*UNIQUE Forestry and Land Use, Germany; sophia.carodenuto@unique-landuse.de;eduard.merger@unique-landuse.de*), Parfait Essomba, E. (*University of Sheffield, UK; epjessombangono1@sheffield.ac.uk*).

Cameroon is currently undertaking the necessary analytical work for preparing a national REDD+ strategy. The first step in preparing this strategy is a systematic assessment of the drivers of deforestation, which provides quantitative and qualitative results that inform policy. This study proposes a methodology for assessing underlying and proximate drivers in a comprehensive framework that allows for the participation of relevant stakeholders, including national and local institutions, while following international best practices regarding technical aspects. The methodology was tested in a pilot area and received critical feedback during a 2-day national workshop. The methodology incorporates the priorities of Cameroon as outlined in its REDD+ Readiness Proposal, including the need to allow for full and effective participation of indigenous people and local communities as well as adaptation to the country's five diverse agro-ecological zones. The added value of this methodology's bottom-up approach is that it allows for a better understanding of the economic incentives, social and environmental co-benefits, and underlying causes associated with the identified deforestation and forest degradation drivers and agents. The results include forest area loss, carbon emissions, and opportunity costs associated with the drivers/deforestation agents. These elements provide crucial background information for developing REDD+ strategy options for the country.

The cost of desertification in China: a literature review. Cheng, L. (*Chinese Academy of Forestry, China; chengleilei@caf.ac.cn*), Low, P. (*Universiti Kebangsaan Malaysia, Malaysia; plow@ukm.my*), Qi, L., Gong, L. (*Chinese Academy of Forestry, China; luqi@caf.ac.cn*); *gongliyan@caf.ac.cn*).

The UN Convention to Combat Desertification (UNCCD) 2nd Scientific Conference in 2013 focused on economic assessment of desertification and its addressing policies and practices. More attention has been paid to economic assessment of desertification, which may be more helpful in designing and identifying appropriate actions for combating desertification than only physical assessment. However, so far no consensus estimate of desertification cost exists in China as well as worldwide, let alone a commonly agreed methodology. This paper reviews the key estimates of desertification cost in China in the existing literature, as well as the methodologies they based on, and the problems they were fraught with. Direct costs including land abandonment and agricultural production loss were estimated by using opportunity cost approach and change in productivity approach respectively. Indirect costs comprising siltation of rivers, reservoirs and irrigation canals and transportation loss were estimated by using replacement cost approach. The existing studies are limited by double counting between different costs, confusion of short-term costs and long-term costs, and lack of necessary adjustment of price parameters. Besides overcoming these limitations, the up-to-date information should be used and more scientific and matured assessment framework should be developed to improve the accuracy of estimate of desertification cost.

An international examination of tax and accounting rules and the impact on forest land ownership. Cushing, T. (*Clemson University, USA; tcushin@clemson.edu*).

The objective of this paper was to look at how forest landowners are taxed internationally. Landownership is changing in the United States as demographics change. Corporate strategies have evolved with the tax code as well as with a greater understanding of comparative advantages. At the same time, global trade has increased. Those trying to influence tax policy desire a better understanding of the costs of growing trees in other countries. In addition, U.S. accounting rules will be changing in 2014 to better align these rules with those of the international community. This change will have an impact on the balance sheets of U.S. forest products companies and investors. This paper examines and compares the taxation and accounting rules in countries that export wood. The focus is on understanding how these rules affect a country's competitiveness in global trade of wood.

Small-scale and community forestry: policies behind the tree-planting movement in Kuningan District, West Java, Indonesia. Damayanti, E., Prasetyo, L. (*Bogor Agricultural University, Indonesia; ellynk.damayanti@gmail.com; lbprastdp@yahoo.com*), Suharfaputra, U. (*Kuningan District Forestry and Estate Crops Office, Indonesia; suharfaputra_ukas@yahoo.com*), Sumirat, U. (*Forestry Service, Kuningan District Government, Indonesia; suharfaputra_ukas@yahoo.com; baraya_pathana@gmail.com*), Nasihin, I. (*University of Kuningan, Indonesia; e03498033@yahoo.com*), Purwadi, H. (*Kuningan District Forestry and Estate Crops Office, Indonesia; purwadi.hd@gmail.com*).

A study in Kuningan District (West Java Province) by Prasetyo, Damayanti, & Masuda (2012) showed that forest cover decreased in 1997–1999 and increased between 1999 and 2009, during Managing Forest Resources with Communities (PHBM) implementation. Reforestation was successful in PHBM villages because the people were aware of the current and future benefits of the PHBM, and people realized that the government was acknowledging the property rights of local people. Further study (Damayanti and Prasetyo, 2013) incorporated a longer period of forest cover change data (1978–2009) and a household survey of kebun and private forest owners. Results showed that people in Kuningan District enthusiastic about planting trees. Among the reasons for their interest were: modest input required for tree planting, passive management, lack of water for planting agricultural crops, and the increasing price of timber. The current study will address the policies of the Kuningan District Government in relation to land use planning, reforestation, land rehabilitation, and people's welfare, as well as local communities' perspective on the policies. Tree planting is one of the district government's programs that have been introduced on government lands (developed as botanical gardens and villages' urban forest), and it also touches every aspect of people's lives, including development of private forest.

Capacity development needs assessments for improved governance of community forestry. De Bruyn, T., Greijmans, M. (*Center for People and Forests (RECOFTC), Thailand; toon.debruyn@recoftc.org; martin.greijmans@recoftc.org*).

Community forestry is seen by many to be a credible tool for the pursuit of sustainable forest management. Successful governance in community forestry is highly dependent upon who is involved, and upon the capacity of those participants to realize rights to and responsibilities for access, use, and management of forest resources. There are many prescriptions for capacities needed for community forestry development, but a systematic approach to assess the actual needs is not available. This is underlined by the lack of research in this area. The paper will explore the pre-conditions for the identification of capacity needs, presenting and commenting on a nested approach to assess the needs. It will present a framework for this approach that reflects the experiences of practitioners that used this guideline in six countries in Asia. It will also share key findings, and give recommendations for future assessments and for the role of the assessments in developing successful governance of community forestry. The governance implications cover participation, accountability, transparency, effectiveness, efficiency, and fairness/equity of community forestry development.

Efficiency in development cooperation: the experience of the Ibero-American Model Forest Network and its Model Forests. De Camino, R. (*Red Iberoaméricana de Bosques Modelo (RIABM) – CATIE, Costa Rica; rcamino@catie.ac.cr*), Carrera, F., Villalobos, R. (*CATIE, Costa Rica; fcarrera@catie.ac.cr; rvillalo@catie.ac.cr*).

Model Forests (MF) are local social platforms created through an international initiative for the management of forest-rich territories. As a bottom-up approach, they provide good governance to territorial constituencies committed to sustainable human development. Nowadays, international resources are scarce and sometimes too donor-driven. The 25 Model Forests and 15 member countries of the Ibero-American Model Forests Network have shown resilience against the scarcity of resources as well as a very high resources multiplier. Preliminary estimates suggest that this multiplier is more than 20. After consultation with the network's secretariat, the study reviews the contributions of the member countries and of the individual Model Forests to the

operation of the system. This study shows that MFs are creative in formulating ideas and are capable of channeling local, national, and international cooperation resources, not only for local projects but also for initiatives that cover more than one country and more than one MF. Additionally, MFs receive support from national and local governments, which consider them a useful governance platform for the implementation of national natural resources policies. The paper concludes that with proper focus and will, it is possible to implement many sustainable-development initiatives benefiting forests and people, even when resources are limited.

Local team leadership for sustainable development: the case of the Model Forests of the Ibero-American Network. De Camino, R. (*Red Iberoaméricana de Bosques Modelo (RIABM) – CATIE, Costa Rica; rcamino@catie.ac.cr*), Villalobos, R., Lorenzo Lemire, J. (*CATIE, Costa Rica; rvillalo@catie.ac.cr; josique@catie.ac.cr*).

Conventional wisdom states that the success of any enterprise is linked to leadership. However, there are different types of leadership and different qualities associated with it. In relation to the sustainable development of forest-rich territories, the decisions should not be made by a single authority or individual; instead, given the complex mixture of rights and interests at the territorial scale, agreement should be reached through participatory processes. The objective of this research is to compare the principles, design elements, and enabling conditions of empowered participatory governance (EPG)—a concept introduced by A. Fung and O. Wright in 2003—by analyzing the experience of the 29 Model Forests and 15 member countries which belong to the Ibero-American Model Forest Network (RIABM). The authors identify new variables that are important in a rural/forest context and that need to be addressed in the concept of EPG; they then show how these variables operate at the Model Forest level. The key element identified is team leadership, precisely because of the complexity of the interactions and the diversity of stakeholders with their particular and sometimes conflicting interests. Examples of the meaning of "team leadership" in the praxis are given.

Identifying potential sources of conflict in different types of intervention to community land and forests. Dhiaulhaq, A., Gritten, D., De Bruyn, T., Greijmans, M., Oro, J. (*Center for People and Forests (RECOFTC), Thailand; ahmad.dhiaulhaq@recoftc.org; david.gritten@recoftc.org; toon.debruyn@recoftc.org; martin.greijmans@recoftc.org; jephraim.oro@recoftc.org*).

Conflict over land and forest management is widespread and often unavoidable due to competing interests and values. One of the most common types of conflicts is community-outsider conflict, which often takes place when external actors do interventions (e.g., plantation development) on land and forests that has been managed by the local community. To minimize the negative impacts of conflict and to inform proper approaches to conflict transformation, identification of the conflict sources is essential. This study presents an analytical framework to identify possible sources of impairment during the process of external intervention on community land and forest, which may result in conflict. The framework was developed from an extensive literature review and was tested on 14 conflicts or potential conflict sites in six Asian countries. Preliminary results show the potential relevance of the framework, for example in helping to flag issues that may lead to conflict and therefore require greater attention in the process of any external forest and land intervention. The framework can serve as a useful methodological foundation for future research on this type of conflict. The results of this study can be applied to other types of intervention such as REDD+, foreign direct investment, and protected area development.

Restoring nature: combining "new" and "old" policy instruments in Swedish forests. Eckerberg, K. (*Umeå University, Sweden; Katarina.eckerberg@pol.umu.se*), Hjälten, J. (*Swedish University of Agricultural Sciences, Sweden; joakim.hjalten@slu.se*).

Ecological restoration (ER) is seen as a means for solving many of today's environmental challenges, such as climate change mitigation/adaptation and safeguarding ecosystem services, including biodiversity and flood protection. Several political actors, including states and international organizations, such as UNEP, have declared their commitment to engage in ER. Sweden is a country dominated by forests and characterized as being one of the world's forerunners in environmental policy, but how to implement its forest-environmental policy has engendered much public controversy. Sweden thus serves as a case study for studying how "new" and "old" policy instruments for ER are combined and with what results. ER activities are taking place, both as part of the general call for "environmental considerations" in the Forestry Act, as projects within the context of several public funding programmes aiming at ecological sustainability or nature conservation, and as part of the voluntary forest certification systems of Forest Sustainability Council (FSC) and the Programme for the Endorsement of Forest Certification (PEFC), which cover more than half of Sweden's forested area. This presentation discusses the complementarity as well as the tensions between the present policy mixes, and to what extent different notions of ER are supported by the different types of instruments.

Collaborative forest governance of a community forest in western Canada: What is the role of social learning? Egunyu, F., Reed, M. (*University of Saskatchewan, Canada; felicitas.egunyu@usask.ca; mgr774@mail.usask.ca*).

Community forestry is designed to improve the livelihood of local people while protecting forestry resources through sustainable use. Community forestry is intended to be participatory in nature, providing opportunities for people to learn as they manage forestry resources. It is acknowledged and documented that social learning contributes to forest governance in both developed and developing country settings. However, there is a need to further investigate how learning occurs, what is learned, and the effect of learning on forest governance. This study investigates the contribution of social learning to forest governance in the Harrop-Proctor Community Forest in British Columbia, Canada. Semi-structured interviews of 28 community members, five key informant interviews with representatives from government and not-for-profit organizations, and two community-level focus groups were conducted in June–July 2012. Documentary evidence was also collected. Throughout the data collection period, community forestry activities were observed. Results show that most participants started engaging in community forestry with limited knowledge and learned as they participated in lobbying for the community forestry licence, doing management planning, and implementing operations. However, as the community forest became more well-established, many of the learning opportunities and outcomes became more restricted. The presentation will provide details of this apparent paradox.

Fully mobilizing forest potential in the Kyoto Process: on potential future convergence across the REDD+ and LULUCF frameworks. Ellison, D., Petersson, H., Lundblad, M. (*Swedish University of Agricultural Sciences; ellisondl@gmail.com;hans.petersson@slu.se; mattias.lundblad@slu.se*).

The principle of "Common But Differentiated Responsibilities" has dominated UNFCCC-based Kyoto climate conferences. In Durban, however, this principle gave way to calls for a 2020 legal regime that begins to dispose of the distinction between Annex I and non-Annex I states (Aldy/Stavins 2012), and all countries now submit emission reduction commitments under the new post-Kyoto framework. On the periphery of negotiations, the role of forests in the climate policy framework has been discussed in at least two distinct forums: for the developed countries, LULUCF rules have been elaborated under the Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol (AWG-KP). For the developing non-Annex I countries, Agriculture, Forestry and other Land Uses (AFOLU) and REDD+ have been discussed and developed in the framework of the Ad hoc Working Group on Long-term Cooperative Action under the Convention (AWG-LCA). Convergence in Kyoto processes begs the question: Can forests also play a more meaningful role in the international climate policy framework? Key points in the development of an overarching framework concern the compatibility of rules governing forest-based carbon accounting across LULUCF and REDD+, and their inclusion in global emission trading schemes.

Multifunctional and integrated forest management in Italy: policy failures and possible solutions. Favero, M., Pettenella, D., Secco, L., Leonardi, A. (*University of Padova, Italy; matteo.favero86@gmail.com; davide.pettenella@unipd.it; laura.secco@unipd.it; alessandro.leonardi@unipd.it*).

The Italian forestry sector counts for very little in the national economy, despite the vast expanse of domestic forests. This marginal contribution to the economy is the result of technological and entrepreneurial backwardness, and several policy and administrative issues, such as inappropriate governance reforms and strong command-and-control regulations. More recently, the review of public spending has further weakened the link between practitioners in the field and public governance institutions. As a result, multifunctional and integrated forest management has been adopted only sporadically thus far. Moreover, national and forest law, policies, and regulations, along with international ones, appear uncoordinated, inefficient, or ineffective. To better highlight these trends, three regions with very different socioeconomic, administrative, and environmental features were selected as case study areas: Veneto, Molise, and Sicily. Interviews were carried out with local forest stakeholders, and collected information triangulated with data from secondary sources and other qualitative information. The paper argues that the absence of conflicts in the allocation of forest resources is the main problem from which the Italian forest sector suffers. Possible actions to overcome these issues are also discussed, particularly referring to the promotion of voluntary and market-based mechanisms applied to products and services others than wood provision.

Reaching out: the role of Argentine Model Forests in the implementation of the federal forest policy. Gabay, M., Sá, M. (*Directorate of Forestry, Argentina; mgabay@ambiente.gob.ar; msa@ambiente.gob.ar*).

This paper presents the experience of Argentine Model Forests as local-level governance platforms implementing the National Program for the Protection of Native Forests (NPPNF). The NPPNF was established by the Argentine Congress in 2007 within the framework of Law No. 26,331 of Minimum Environmental Standards for the Protection of Native Forests. The program aims at promoting sustainable forest management (SFM) taking into account forest communities and minimizing negative environmental impacts. Argentine Model Forests foster SFM while seeking to improve marginalized and low-income forest communities' livelihoods. The methodology consists of a mixed methods multiple case study involving three Model Forests representing different forest regions. The study analyzes the outcomes of the programs developed through the collaboration local, provincial, and national stakeholders. The prioritized activities involve, among others, bioenergy production, production forestry, non-timber forest products, local added value (capacity building), and silvopastoral activities. The results provide insights into consensus-building processes within multistakeholder partnerships, and the contributions of Law No. 26,331 to enhancing sustainable local livelihoods in forest ecosystems.

Innovative legislation for natural and planted forests in Iran. Ghilichkhani, M. (*Tarbiat Modares University, Iran; masghel52@yahoo.com*).

Most of Iran's 18 million ha of natural forests are in mountain areas, are uneven-aged, and are of mixed species composition. On the other hand, the country's planted forests are around cities and on rangelands or have been planted on forest land after logging. Many methods have been used in the management of these forests, including clearcutting, shelter wood cutting, and selection cutting. Some of these practices under previous legislation contributed to overutilization of forest resources. As conflicts arose over utilization and maintenance of biodiversity, new environmental legislation was introduced. Today regulations and other legislation are being proposed and adopted to mitigate threats to forests, reduce conflicts among user groups, and oversee management of all of Iran's forests for the long term. Scientific research from around the world, views of disparate stakeholders, and local experience have informed this legislation. As a result, a practical and comprehensive legal framework is being established to support biodiversity through management that promotes close-to-nature forests and sustainability.

Demonstration sites for community forestry: Addressing the fundamental challenges of sustainable forest management in Asia? Gritten, D., Suzuki, R., Triraganon, R., Atkinson, J., Dhiaulhaq, A. (*Center for People and Forests (RECOFTC), Thailand; david.gritten@recoftc.org; regan.suzuki@recoftc.org; julian.atkinson@recoftc.org; ahmad.dhiaulhaq@recoftc.org*), Etue, E., Greijmans, M.

Many Southeast Asian countries have ambitious targets for area of forest land under community management; however, with the exception of Vietnam these targets are not being met. The challenges are numerous, including poor understanding of community forestry (CF), and regulatory barriers and capacity issues for government officials and local communities. In order to address these and other challenges, CF demonstration sites are being established in Cambodia, Laos, Myanmar, Thailand, and Vietnam. Aims of the demonstration sites include: (1) ability to compare sites as an opportunity to share lessons; (2) capacity development

for key stakeholders (government officials, members of civil society organizations, and members of other communities); (3) improvement of CF in the sites and beyond, such as by monitoring the impact of targeted activities and identifying best practices, with the idea of scaling up or replicating the activities in other appropriate sites; and (4) visits by relevant stakeholders to see targeted activities (thereby increasing the profile and understanding of community forestry). The aim of this paper is to present frameworks for site selection and for documenting best practices. Anticipated results include understanding whether CF in the region is relevant only on a subsistence level, or whether through various interventions CF can help to address some of the fundamental challenges to sustainable forest management in the region.

Rural livelihood, voluntary partnership agreements, and social safeguards in Ghana. Hansen, C., Pouliot, M., Treue, T. (*University of Copenhagen, Denmark; cph@ifro.ku.dk; mapo@ifro.ku.dk; ttr@ifro.ku.dk*).

The paper assesses the perceived need for social safeguards targeting forest-dependent households in Ghana to mitigate adverse socioeconomic impacts of the voluntary partnership agreement (VPA) under the Forest Law Enforcement, Governance and Trade (FLEGT) Action Plan. Livelihood outcomes of the VPA are assessed against detailed data on forest and livelihood linkages from 478 randomly selected households in two forest-fringe communities as well as national data on logging and timber trade. The paper finds that timber harvesting for subsistence and cash contribute little to rural households' total incomes, which means the direct impact of the VPA on rural livelihoods is likely to be limited. Rather, it is the formal timber industry, small-scale carpenters, and those involved in timber theft and the illegal timber trade who will be negatively affected. But social safeguards aimed at compensating groups for their losses from giving up their illegal activities would be difficult to justify. Social safeguards would thus be unnecessary or immoral, or both. However, long-term positive impacts of the VPA on rural livelihoods and, hence, on forest conservation could be realized, if the agreement helps to bring about governance and forest tenure reforms that enhance rural communities' rights to timber resources and revenues.

Economic instruments to enhance multi-functional forest management of Zagros forests in western Iran. Henareh Khalyani, J. (*University of Tehran, Iran; jhenareh@gmail.com*), Namiranian, M. (*University of Tehran, Iran; namirani@nrf.ut.ac.ir*).

The paradigm of sustainable forest management recognizes that forests are managed for a wide variety of ecological, economic, and social benefits. This approach has become the common theme in forestry throughout the world today. Here the authors explore how to achieve such management from a human-environment perspective using economic instruments. Selected forests in each of the 11 western provinces of Iran in the Zagros region were surveyed concerning programs available to customary forest owners for their livelihoods. These owners manage the forests to provide fodder for livestock, wood for fuel and construction, and land that can be cleared for under-canopy farming. The Iranian government provides incentive programs in non-industrial Zagros forests. The authors performed an institutional analysis of the formal and informal rules of the programs based on a review of the literature and discussions with government officials and local owners. Results indicated that the main reason for mismanagement of Zagros forests is weak social acceptance of management plans. Indigenous people's dependence on the forest for their livelihood showed that local people enjoy substantial economic benefit from forests. Therefore, the needs of people whose livelihoods depend on the forest must be incorporated into sustainable forest management by economic instruments.

Integrated management of forest goods and ecosystem services to achieve sustainability in forest management in the mountainous Zagros forest of Iran. Henareh Khalyani, J., Namiranian, M., Makhdoom, M. (*University of Tehran, Iran; jhenareh@gmail.com; namirani@nrf.ut.ac.ir; majidfmekhdoum@yahoo.com*), Mobarghei, N. (*Shahid Beheshti University, Iran; n_mobarghei@yahoo.com*).

Forest ecosystems deliver goods and services of enormous value to people. Zagros forests, which make up 40% of the national forests in Iran, are the primary site for this study. Population growth, shortage of productive lands, rural poverty, and local communities' intensive utilization of forest, have caused demand for goods and services from the Zagros forest to exceed the ability of traditional management to meet demand. The authors used the concept of human-environment systems as the rationale for this research. Detailed information was obtained from a survey of local communities through quantitative and qualitative participatory methods. The study revealed that livelihood of most people in the Zagros forest is based on a combination of forest products, animal husbandry, and dry agriculture, all of which are highly dependent on forest lands. To achieve balance in supply and demand for forest goods and ecosystem services based on the integrated management approach, a soil-based productive agricultural system should be the top priority. Furthermore, rural communities in the Zagros forest should be of primary consideration in sustainable forest management. Promotion of sustainable use of non-timber forest products is recommended to alleviate poverty and conserve forest. Results from the study will help in the development and implementation of management models that consider forest ecosystem goods and services.

Current status and potential for forest certification in Vietnam. Hoang, H. (*Kyoto University, Vietnam; hai.htn@gmail.com*).

Although Vietnam is one of Southeast Asia's largest exporters of wood products, its enterprises have to import 80% of their raw materials, making them vulnerable to fluctuations in wood supply and price. Forest certification was introduced in the 2000s with the aim of bringing economic, social, and environmental benefits. There are several factors hindering implementation of forest certification. First, the institutional and legal framework is not complete. Although the timber-processing industry has developed rapidly, it is still unstable, lacks strategic vision, and is in a weak competitive position. Second, most of Vietnam's wood-processing industry is small or medium-size. Third, awareness of the importance of forest certification is limited. On-the-ground forest managers and employees of forest management businesses do not have a good understanding of what it entails and what it offers. Fourth, the certification fee is high. Finally, investment remains a problem in Vietnamese forestry. Under the 2006–2020 strategy, $400 million is needed annually, yet current investment from public and private sources is only $50–60 million. However, there are opportunities for forest certification. Forestry has become a market-oriented enterprise involving many sectors. The Vietnamese government set a target for, 30% of forest production to be certified by 2020. A national system for certification is being developed. With forest certification, Vietnam is making progress in sustaining its resource.

Cost-benefit analysis of producing and refining cellulosic ethanol from *Pennisetum purpureum.* Huang, M. (*National Chiayi University, China-Taipei; myhuang@mail.ncyu.edu.tw*), Chiang, A. (*National Chengchi University, China-Tapei; eliot.chiang@gmail.com*), Liu, K. (*National Chaiyi University, China-Taipei; s1000091@mail.ncyu.edu.tw*).

China-Taipei imports about 97% of its energy from other countries. Because of worldwide instability, this country may face great uncertainty in its energy supply. Further, concern about the increasing scarcity of some fossil fuels and about greenhouse gas emissions from combustion of fossil fuels has led to international interest in bioenergy as one alternative energy source. This study develops a management plan of cellulosic ethanol production using *Pennisetum purpureum.* The study is based on the report of the National Renewable Energy Laboratory in 2011 and evaluates the management plan by applying cost-benefit analysis. The two scenarios set two different levels of biomass input from *P. purpureum*: basic scenario 1 (pilot plant scenario) with 14 million tons of inputs and basic scenario 2 (commercial scenario) with 70 million tons of inputs. Each scenario then incorporates grants for fallow land and carbon-trading sub-scenarios in a separate step. As a result, there are no economic incentives in the basic scenarios. However, if both fallow-land grants and carbon-trading sub-scenarios are included in basic scenario 1, the pilot plant would have positive economic gain. For basic scenario 2, in contrast, the addition of either fallow-land grants or the carbon trading sub-scenario generates good economic revenue.

Long-term structural drivers of sawnwood consumption in Europe. Hurmekoski, A., Hetemaki, L.(*European Forest Institute, Finland; elias.hurmekoski@efi.int; lauri.hetemaki@efi.int*).

Sawnwood demand modeling typically uses explanatory variables that mostly reflect business cycles of economic activity, and there is limited empirical research on the structural determinants of sawnwood demand. The first of the two objectives of the study is to identify potential factors that affect the observed differences in the long-term level of sawnwood consumption in Europe, i.e., the market share of wood compared to other construction materials. The empirical analysis uses consumption per capita as the dependent variable. Adjusting for population (i.e., the size of the markets) makes the model more comparable among different regions and is seen to better account for structural drivers in the sawnwood markets, compared to absolute values. Differences in the level of consumption between aggregate regions appear to be rather persistent, but major changes in the per capita consumption of sawnwood have occurred on a country level. These changes likely cannot be explained by the traditional demand shifters based on microeconomic theory alone. In order to discuss the possibility of similar changes elsewhere and on a larger scale, the second objective of the study is to identify and evaluate potential factors that cause changes in the market share of wood in the construction markets, which the demand equations reflecting business cycles and the size of economy are less suited to capture.

Adaptation to climate change through community forestry programs – case studies in vulnerable uplands of the Philippines. Jarzebski, M. (*University of Tokyo, Japan; marcin.jarzebski@yahoo.com*), Tolentino, P. (*University of the Philippines, Philippines; plmtolentino@gmail.com*), Yamamoto, H. (*University of Tokyo, Japan; yama@k.u-tokyo.ac.jp*), David, C. (*University of the Philippines, Philippines; cp.david@yahoo.com*).

Adaptation to climate change is a crucial issue for sustainability. For the Philippines, projected changes in climate include droughts, excessive precipitation, and an increase in temperature. These changes will negatively affect agricultural crops and the life of people across the country. Especially vulnerable are uplands where community forestry programs are mostly located, as these areas are subject to reforestation and conservation of forest. In addition to reforestation, the Community Based Forestry Management program provides livelihood assistance as cash crops and training. However, it is uncertain if the program is building adaptation to changing climate. For this study four areas located in the Philippines were analyzed in terms of climate change adaptation. The first step was to forecast climate change by the year 2050, by using the Modeling System for Agricultural Impacts on Climate Change (MOSAICC). The second step was to assess Community Based Forest Management's strategies, including varieties of plants, cash crops, and trees that have been promoted, and capacity-building programs. Research showed that there is low preparedness for climate change, which may cause hindrances for future development of forest-dependent communities. The current agenda has been advanced with the purpose of making communities more resilient in current conditions, but does not deal with adaptation to forecast climate changes.

Legal aspects of non-wood forest products in Western Balkan countries. Keca, L. (*University of Belgrade, Serbia; ljiljana.keca@sfb.bg.ac.rs*), Avdibegović, M. (*University of Sarajevo*, *Bosnia and Herzegovina; mavdibegovic@gmail.com*), Keca, N. (*University of Belgrade, Serbia; nenad.keca@sfb.bg.ac.rs*).

The aim of this paper is to analyze the legal framework pertaining to non-wood forest products (NWFPs) in the Western Balkan countries. The collection and use of NWFPs have a long tradition in WB countries because of this region's very rich biodiversity. Although in the last few years WB countries have enacted some updated laws and regulations pertaining to forestry, some articles of which regulate NWFPs, it is important to emphasize that these products are covered by laws in other areas, particularly those dealing with nature and environmental protection. Research for this paper is based on a review and comparative analysis of laws and regulations in the areas of forestry, nature conservation, and environmental protection in selected WB countries. The goal of this paper is to determine legislative points governing NWFPs through examination and analysis of WB laws and other legal documents.

Development of marketing activities in production of logs in Serbia. Keca, L., Keca, N. (*University of Belgrade, Serbia; ljiljana.keca@sfb.bg.ac.rs; nenad.keca@sfb.bg.ac.rs*), Avdibegović, M. (*University of Sarajevo, Bosnia and Herzegovina; mavdibegovic@gmail.com*).

This article deals with product placement of logs in Serbia with the goal of identifying commercial marketing opportunities. The aim of the research is to demonstrate the importance of marketing activities in forestry and the wood processing industry, especially for sale of wood from small-dimension logs and finished products in Serbia. To analyze marketing instruments for the production and sale of logs and products made from them, the authors used the concept of the marketing mix (the four Ps:

product, price, place, promotion). This concept is useful for enterprises that are striving to increase demand for their products. Logs are mainly produced from pines. The authors' research area focused on the range for European black pine, and on log production in Kremna, about 30 km from Užice (Serbia). Log production and sales increased in the period 2005–2009. Log prices are not determined by market forces but are set by the method of costs. Distribution largely occurs through short channels (producer, consumer), and, in some cases, extended channels (producer, industrial distributor, industrial customer). Promotional activities are very modest, such as participation in fairs and advertising in catalogs and flyers.

Local community participation in forest management in Lombok, Indonesia. Kim, I. (*University of British Columbia, Canada; inae.kim@alumni.ubc.ca*), Bae, J. (*Korea Forest Research Institute, Republic of Korea; forestory@forest.go.kr*), Latifah Endang Sunarya, S. (*University of Mataram, Indonesia; slatifa23@yahoo.com*).

The purpose of the research is to identify how the people of Lombok participate in forest management. A participatory rural appraisal was used. A focus group discussion and household survey in 14 villages around West Rinjani, Lombok were conducted. Although social forestry programs have been in place in Indonesia since 1998 (reformasi), the programs face challenges and opportunities in on-the-ground implementation. Community-led social forestry includes community forestry (Hutan Kemasyarakatan), the planting of forests by people (Hutan Tanaman Rakyat), and village forests (Hutan Desa). The government-led social forestry program is the rural community's participatory forest management program (PHBM). In Lombok, community forestry has positive impacts on the local communities. However, getting a permit for community forestry programs is a complex and expensive process. The community forestry program is not easy to implement on the ground, but the local forestry agency does initiate agreements with local communities for sustainable forest use and has implemented a forest watch program that is the modern version of the traditional forest watch. The local forestry agency plays a key role viable options for institutionalized social forestry programs in the West Rinjani protection forest, Lombok.

Wildfire economics: historical challenges and future directions for estimating ecosystem service values of fuels management in western U.S. forests. Kim, Y. (*Northern Arizona University, USA; ysk@nau.edu*), Wu, T. (*Arizona State University, USA; tongwu86@gmail.com*).

The management of forest fuels to address wildfires is a longstanding environmental issue in the United States, and one that will become more urgent with the continuing encroachments of residential development and climate change. Despite a lengthy history of fuels management, the economic impacts of past policies, and the likely outcomes of current efforts, have been the subject of much debate. The cost-benefit balance of fuels management, especially with relation to wildfire risk reduction and ecosystem service values, is a particularly vague area. A summary and synthesis of the existing literature and case studies will be presented, highlighting the conceptual bases and empirical weaknesses of our current understanding of wildfire economics. The authors hope to generate constructive discussions to identify future research directions.

Discount options as a financial instrument supporting REDD+. Krasovskii, A., Khabarov, N., Obersteiner, M. (*International Institute for Applied Systems Analysis (IIASA), Austria; krasov@iiasa.ac.at; khabarov@iiasa.ac.at; oberstei@iiasa.ac.at*).

This research is focused on developing financial instruments in the framework of REDD+. The proposed microeconomic model deals with the interaction of the forest owner, electricity producer, and electricity consumer. The producer initially has a fixed installed capacity of technologies varying in costs and emissions. The profit maximization problem is solved by choosing the optimal capacity factors to satisfy the daily electricity demand. The electricity price that consumers are willing to pay for the given yearly production is described by their inverse demand function (linear, constant elasticity). Exploration of scenarios for rising CO_2 prices shows an increase in electricity prices and decrease in profits and emissions with nonlinearities due to technology mixes. The producer can buy discount options as a hedge against the risk of high CO_2 prices Given the market CO_2 price, the producer maximizes its profit by taking the discounted price. The producer and forest owner negotiate the "fair" option price based on their expected CO_2 prices. The authors show that the proposed financial instrument has the potential to increase the producer's profits and decrease electricity prices for the consumer, but public money might be needed to support it.

Analysis of the economic effects of community forestry on rural households in the Mid-hills of Nepal. Lamichhane, D. (*Ministry of Forest and Soil Conservation, Nepal; dlamichhane@gmail.com*), Parajuli, R. (*Louisiana State University, USA; rparaj1@lsu.edu*).

The community forestry program (CFP) has been considered as playing an important role in the rural economy of the hilly region in Nepal. The paper evaluates the impact of the CFP on the household economy of the forest users of four community forest user groups (CFUGs) from two hilly districts. Data were collected from rich, middle, and poor wealth ranks of the forest users by using a questionnaire, field observation, and focus group discussion. Monetary value for direct and indirect benefits (B), considering selected good and services, and direct and indirect cost structures (C) of a household associated with community forests were calculated and analyzed according to the wealth ranks of households. Contingent valuation methods were applied for valuing indirect benefits and costs. The research findings indicated that the net direct benefits were all positive, and net indirect benefits were all negative in the three wealth ranks. However, the B/C ratios of different benefits and costs suggested that the CFP had positive economic impact on the rich (B/C >1) but negative on the middle and poor households (B/C <1). By holding the high proportion of benefits and low proportion of costs, the rich have generated negative externalities that have an impact on households in the middle and the poor classes.

Evaluating additionality and leakage issues from voluntary participation in forest carbon offset programs. Latta, G. (*Oregon State University, USA; greg.latta@oregonstate.edu*).

An intertemporal partial equilibrium model of the U.S. forest sector is modified to assess the market, land use, and greenhouse gas implications of a voluntary carbon offset program for improved forest management. Results over a range of carbon prices and offset program rules are evaluated for market participants as well as non-participants. In this modeling exercise additionality

is demonstrated by landowners who enroll at low carbon prices with no management change, and leakage is calculated as the ratio equal to the carbon change on non-participating lands divided by the carbon change on participating land over the full range of prices. Implications of restricting offset allocations to carbon fluxes in forests with greater than average carbon stocking levels are examined, as are implications of including payments upon project initiation to participants with initial stocks greater than average stocking. In addition to quantifying additionality and leakage impacts to the U.S. forest sector, results highlight the complexity of accounting for those interactions in methodologies aimed at quantifying improved forest management emissions reductions.

Competition for biomass in a declining pulp and paper market with an evolving renewable energy policy. Latta, G. (*Oregon State University, USA; greg.latta@oregonstate.edu*), Sjølie, H., Solberg, B. (*Norwegian University of Life Sciences, Norway; hanne.sjolie@nmbu.no; birger.solberg@umb.no*).

Forests have an important role in mitigating climate change by sequestering carbon during growth and supplying raw material for bioenergy and solid wood production. Bioenergy policies, extensively applied in industrialized countries, are increasingly being used to foster the expansion of nascent biofuel and biopower industries. These targets are frequently coupled with sustainability criteria in recognition of the host of ecosystem services forests provide. Evaluating potential market responses is complex as it involves the interaction between the existing forest inventory, silvicultural investment, harvest rates, wood utilization, and industrial structure as well as the associated changes in prices and trade levels. This study uses Norway as a case study, evaluating its forest sector bioenergy potentials given a string of recent paper mill closings and an annual increment in excess of harvest levels. The authors incorporate new long-term income elasticities for paper demand to recognize the structural shift in demand due to increasing competition between paper and electronic media. Two forest sector partial equilibrium spatial models are applied in combination to endogenously determine the discrete decision timing of optimally converting existing facilities to biofuel production. These models simultaneously minimize the impacts of declining paper demand and provide comprehensive greenhouse gas accounting and detailed representation of forest management addressing sustainability concerns.

On the economics of forest carbon: renewable and carbon neutral but not emissions free. Lintunen, J., Uusivuori, J. (*Finnish Forest Research Institute, Finland; jussi.lintunen@metla.fi; jussi.uusivuori@metla.fi*).

First-best optimal forest sector carbon policy is examined. The authors show that renewability and carbon neutrality arguments do not warrant emissions-free treatment of forest bioenergy. However, emissions-free treatment of wood in material and energy use is justified under the carbon accounting followed by IPCC, but only when the supply-side policy targeting forest owners accounts for corresponding emissions. The authors show how, in the optimal policy, bioenergy from harvest residues is not treated as emissions free, although their effective emissions are below their nominal emissions, and depend on decay lifetime and discount rate. The subsidy on harvested wood products is based on product lifetimes and discount rate, whereas the supply-side policies are independent of final use of harvested timber. Numerical solution of the model shows that, although the use of wood is not emissions free, it is optimal to increase the total use of wood, including in the energy sector. The supply-side policies lead to an initial drop in harvests, which allows for accumulation of older stands, resulting in larger yield and higher wood utilization.

Overview of participatory forestry in China. Liu, J. (*Renmin University of China, China; liujinlong@ruc.edu.cn*).

This paper analyzed the achievements and contribution of participatory forestry to sustainable forest management (SFM) in China over the last decade. Participatory forestry was considered an ideology and mindset, which could be summed up as the participatory development concept in forest management. This concept has been applied in a dynamic and evolving process towards implementing SFM, to be accomplished by integrating forest management with rural development; ensuring community participation and benefits from forest management; and reforming policy, legislation, and forestry administration to adapt to rapid social changes. Over 20 years, participatory forestry has been piloted at the community level, scaled to the regional level, and institutionalized in policy at the national level. Research and practices have made great progress in improving the forest and community culture; scaling up a procedure for participatory forest management; improving forest land tenure, the economy, and the forest management model; reforming forest management; and building capacity. Participatory forestry has become one of the discourses for sustainable management of Chinese forests. However, challenges remain, such as institutional barriers, poor research and practices, and lack of successful cases as examples to be duplicated. It is recommended that to achieve a greater contribution from participatory forestry, China should require decentralization of forest management, clarification of forest tenure, and improvement of cooperation among a variety of sectors, by integrating the concept of participatory forestry into key forestry programmes and enhancing capacity building.

Brazilian national forestry production chain identification based on the 2005 Brazilian Institute of Geography and Statistics input-output matrix. Loest, M., Hoeflich, V., Nuñez, B. (*Federal University of Paraná, Brazil; mrloest@yahoo.com.br; vitor.ufpr@gmail.com; blas@ufpr.br*).

Strategic planning in the forestry industry requires accurate information reflecting real-world conditions. Only on the basis of good information is it possible to manage and stimulate the forestry industry. The forestry sector presents a complete and complex production chain, responsible for up to 3% of the world gross domestic product, and contributes extensively to many Brazilian production chains. Seventy-six percent of the sector's intermediate products are used by other production chains. Its importance is reinforced by the fact that the other 24% of its product (used by the forestry chain) accounts for 67% of the aggregate value of the forestry production chain. The strong relationship between the forestry sector and other sectors demonstrates not only the importance of this sector but also the degree of interdependence with the other sectors. The Brazilian national input-output matrix from the Brazilian Institute of Geography and Statistics (IBGE) can be used to evaluate the forestry production chain and is a resource useful in forestry sector planning. This article intends to present characteristics of the Brazilian forestry production chain in qualitative and quantitative terms based on the 2005 IBGE's input-output matrix, to identify its components, and to demonstrate the sector's interdependence.

Discussion of House Project Bill 30/2011 for Brazilian Forest Code and changes in permanent preservation areas in the basin of Rio Pardo. Lopes, M. (*Federal University of Rio Grande do Sul, Brazil; manoelasm@gmail.com*), Vassali, M. (*Federal Rural University of Rio de Janeiro, Brazil; mauriciovassali@gmail.com*).

The discussion about the changes in Brazilian Forest Code is a recurring theme in the country, generating numerous conflicts between the opinion of the rural caucus and environmentalists in Brazil. The present study aimed to evaluate the differences in permanent preservation areas (APP) in the basin of Rio Pardo, Rio Grande do Sul, through a comparative analysis between the Federal Forest Code (Law No. 4.771/1965) and House Project Bill No. 30/2011, using geotechnology. As a result, the division of APP in accordance with Law No. 4.771/1965 guarantees a protected area of 28 558 ha, including a 500-m-wide vegetation buffer on riverbanks. The APP defined under the PLC 30/2011 showed an area of 6 715 ha because the riparian buffer is only 100 m wide. Allowing a narrower buffer will only increase damage to the study area in relation to the environment and its biodiversity.

Relevant aspects of valuation of land in investment analysis. Macedo, J., Hoeflich, V. (*Federal University of Paraná, Brazil; joelzmacedo@gmail.com; vitor.ufpr@gmail.com*).

A project can be understood as a set of information internal and external to the company, collected and processed in order to analyze investment decisions. Data analysis is used to determine fixed factors and form the basis for the combination of variable factors of production, in order to obtain a final product resulting from a combination of these materials. The land factor deserves special attention in investment decisions, especially when large areas of land or heavy financial investment is involved. In economic feasibility studies of forestry projects, some authors, such as Boulding (1955) and Duer (1972), ignore the cost of land, justifying this approach by the lack of alternative land use or when land is used solely for forest production. In economic feasibility studies in Brazil, it is common to take into account alternative land uses in most regions by assigning an arbitrary land compensation, with rates ranging from 4 to 15% per year on the value of the land. However, other aspects must be considered, such as the productivity of the land available for other productive factors needed for land cultivation, marketing channels, and market price for the product.

Remuneration of land in forest investment analysis. Macedo, J., Hoeflich, V. (*Federal University of Paraná, Brazil; joelzmacedo@gmail.com; vitor.ufpr@gmail.com*).

Services that are provided by factors of production are incorporated into the production process in the form of added value. In this process, the economic system follows a basic principle according to which the owners of factors of production receive payment for use equal to the value that they create when providing productive services. When the supply factor is fixed, its contribution is considered a "pure economic rent" and its amount depends on current demand. Economic rent is the income of a factor of production in excess of its opportunity cost. Given the above, the objective of this research is to verify feasibility studies in which this methodology is used to account for the land factor in the analysis of forestry investments. The scope of this study is limited to publications in Qualis International journals A1 to B2, as indexed in Scientific Electronic Library Online (SciELO). The study of land compensation is justified by the following: If a factor of production is not being paid for correctly, the study is not properly covering all production costs. The authors' analysis of 299 articles found that all but two used an arbitrarily defined method and other remuneration, with rates ranging from 4 to 15% per year.

Sustainability impact assessment for development of a local bioenergy supply chain: a case in the Como Lake area, Italy. Martire, S. (*European Forest Institute, Finland; salvatore.martire@efi.int*).

Decision-making should be supported by assessment tools able to consider different aspects related to the sustainability of processes. Local policies aim to merge the local community's needs with the objectives of multilevel regulations. For European rural areas, the role of forests has expanded to include leading rural development, as emphasized by the EU Forestry Strategy 2013. The role of forests as a source of fuel is well known, and using local energy resources boosts energy security. Usually, the main constraint for developing local energy facilities is economic feasibility. In addition, utilization of energy supplies causes environmental impacts along the whole chain and the depletion of natural resources. The study aims to contribute to the development of integrated assessments for local planning for rural development and sustainability. The authors applied a comprehensive method capable of supporting decision-making processes at the local scale in order to understand the benefits to local stakeholders and decision-makers of combining environmental, social, and economic aspects in one analysis. Specifically, the assessment aims to support the planning of a local bioenergy chain in Italy. A sustainability impact assessment was carried out though the software ToSIA. Energy development scenarios were compared using environmental, economic, and social indicators.

Participation of women in forestry activities: the case of women as an invisible workforce in Ecuador. Mejia, E. (*Center for International Forestry Research (CIFOR), Ecuador; k.mejia@cgiar.org*), Pacheco, P. (*Center for International Forestry Research (CIFOR), Indonesia; p.pacheco@cgiar.org*).

In Ecuador, men own nearly three-quarters of land in agricultural production, even though women make up 42% of the agricultural labor force. In the Amazon region, labor markets have provided women with cash income, especially from crop and forest commodities. In order to better understand women's participation in labor markets, two research sites were selected in the Northern Amazon of Ecuador. An historical analysis was conducted on labor markets in relation to the investment and political will to increase commodities participation in the Amazon Region. Further, a semi-structured questionnaire was applied to women (n=60) using variables related to: (1) participation, (2) skills, (3) degree of responsibilities, (4) freedom to make decisions (e.g., regarding divorce or migration), and (5) land security. Preliminary results show that several shifts have occurred over time where women undertook predominantly male activities (mostly due to scarcity of labor or need of specialization). In many cases, women do not receive compensation for their work in forestry activities, but do so for agricultural activities. In addition, women receive better income than men when working for third parties on crop activities, which gives them more bargaining power when seeking legal land titling.

Human impact on the land cover in the area surrounded by the centres of past mining. Merganicova, K., Merganič, J., Sitko, R., Mistrik, M. (*Technical University in Zvolen, Slovakia; merganicova@tuzvo.sk; j.merganic@forim.sk; roman.sitko@tuzvo.sk; mistrik@tuzvo.sk*).

The land of Central Europe has long been influenced by human activities. In the Middle Ages, the areas around mining centres were affected the most because of increasing demand for wood. As early as the beginning of the 15th century, mines had inadequate wood supplies. In some cases, wood and charcoal were transported from several tens of kilometres away. The present study assesses the land cover change of the University Forest Enterprise of the Technical University in Zvolen, located in central Slovakia and surrounded by famous mining towns of the past (Banská Bystrica, Kremnica, Banská Štiavnica). The historical development of the land cover of the selected region is determined by using the historical military maps of the Austrian-Hungarian Habsburg monarchy covering the period since the late 18th century, and the archive aerial orthophotos from the recent past (1949, 1977, and 2011). Results of the study indicate that at the end of 18th century, deforested areas occurred mainly around villages. The more recent aerial photos show the reverse trend. Forest expansion in the second half of the last century is mainly related to the abandonment of farmland.

Present and future legal framework of environmental services in Argentina. Minaverry, C. (*Universidad de Buenos Aires & CONICET, Argentina; cminaverry@derecho.uba.ar*).

Argentine legislation does not regulate environmental services for all natural resources. Argentina historically has not applied a consistent approach to legal protection of natural resources. One exception is national law for the environmental protection of native forests, which stated that environmental services are "tangible and intangible benefits provided by ecosystems from native forests, which are necessary for the living of a natural and biological system as a whole, and in order to improve people's life quality." Environmental law should create a technical mechanism which internalizes payment for environmental services provided by all natural resources. To implement this system, environmental services will have to be evaluated economically, just as a value is put on damages to the environment, bearing in mind that this monetary quantification is very difficult to calculate.

Legacies of historical land use on present forest structure in mixed beech-silver fir forests in the Northern Apennines. Motta, R., Meloni, F. (*University of Turin, Italy; renzo.motta@unito.it; fabio.meloni@unito.it*), Garbarino, M. (*Marche Polytechnic University, Italy; m.garbarino@univpm.it*), Berretti, R. (*University of Turin, Italy; roberta.berretti@unito.it*), Urbinati, C. (*Marche Polytechnic University, Italy; c.urbinati@univpm.it*), Bottacci, A., Borchi, S., Bresciani, A.

This study was carried out in three forests characterized by a different past land use and located in the "Foreste Casentinesi, Monte Falterona, Campigna" National Park. The "Verna" forest has been managed by the Franciscan religious order for centuries, the "Camaldoli" forest has been managed by Camaldolese monks for centuries and, more recently, by the Corpo Forestale dello Stato (State Forestry Corps), and the "Sasso Fratino" forests have been sporadically managed in the last centuries. The three forests are characterized by the presence of silver fir, a conifer closely tied to the history of the religious orders, which applied different silver fir "monastic silviculture." The authors analysed forest and coarse woody debris structure and forest regeneration in a network of 30–40 sampling plots in each forest. Even though the three forests have been protected (Sasso Fratino) or managed with a low intensity silviculture (Camaldoli and Verna) in recent decades, legacies of land use activities continue to influence ecosystem structure and function. Current dynamics reflect both the different past land use and the different spiritual expectations of the monastic orders.

New national forest policy of the Russian Federation: basis for solving forest sector problems. Nikitin, V., Sanaev, V. (*Moscow State Forest University, Russian Federation; nick@mgul.ac.ru; rector@mgul.ac.ru*).

The ecological, economic, and social value of Russian forests make it necessary for the Russian Federation to have a long-term state forest policy. The basic provisions of the National Forest Policy of Russia adopted in October 2013 follow. (1) Management: The State provides sustainable forest management even as it utilizes the resources of the forests. The forest management system is based on the separation of powers between central and local authorities. (2) Use: Use of forest resources must be focused on preservation and enhancement of the social and ecological importance of forests as well as on the satisfaction of society's demand for forest resources. (3) Environment: Forest management in Russia promotes preservation of the ecological potential of forests and their capacity for adaptation to climatic changes. (4) Science and education: Forest science plays a key role in gaining new knowledge about the nature of forest ecosystems, which in turn provides a basis for forest management. (5) Society: The State guarantees free access for citizens to forests and to utilization of food and non-wood resources. (6) International aspects: Russia considers the international processes on forests vital for its own economy and ecology, and treats them as a condition of world economy stabilization and preservation of biospheric balance on the planet.

Voluntary Partnership Agreement on Forest Law Enforcement, Governance and Trade between the Republic of Indonesia and the European Union: Who gains the benefits? Nurrochmat, D., Dharmawan, A. (*Bogor Agricultural University, Indonesia; dnrochmat@yahoo.com; aryahadidharmawan@yahoo.com*).

The Voluntary Partnership Agreement (VPA) on Forest Law Enforcement, Governance and Trade (FLEGT-VPA) between the Republic of Indonesia and the European Union was signed in Brussels, Belgium, on 30 September 2013. This agreement recognised the Indonesian Timber Legality Verification System (*Sistem Verifikasi Legalitas Kayu*/SVLK), which deals with the mechanism, process, and establishment of forest management and trade of timber whose legality is guaranteed, in compliance with the European standards. However, the benefits of SVLK compared with several other timber trade policies, such as Log Validation Certificate (SKSKB), Timber Origin Certificate (SKAU), the state mandatory certification system for sustainable forest management (PHPL), and the third party voluntary sustainable forest management certifications, need to be evaluated scientifically. As a part of timber trade policies, the SVLK has to consider political and social-economic priorities, including paying attention to the voices of the poorest and the marginalized. This study determines whether the implementation of SVLK is in accordance with the principles of efficiency, effectiveness, and equity. These have to be able to work together with the pillars of sustainable forest management, and the system shall also support the creation of a transparent, accountable, and law-abiding timber trade.

Addressing the drivers of deforestation: exploring synergies between REDD+ and forest policy. Obersteiner, M., Kraxner, F., Mosnier, A., Bocqueho, G., Khabarov, N., Havlik, P. (*International Institute for Applied Systems Analysis (IIASA), Austria; oberstei@iiasa.ac.at; kraxner@iiasa.ac.at; mosnier@iiasa.ac.at; bocqueho@iiasa.ac.at; khabarov@iiasa.ac.at; havlikpt@iiasa.ac.at*).

This presentation will contribute to increased understanding of the drivers of tropical deforestation and degradation. Key opportunities for new forest sector lead collaborations and more effective future interventions based on forest and land-use policies will be identified. The latest research on drivers and the status of current demand- and supply-side forest sector initiatives will be presented. An overview of new, innovative ideas, which can feed into the UNFCCC negotiations on drivers and other government, industry, and multistakeholder forums will be discussed. Models of unlocking forest finance will be presented. Public finance is used to leverage private finance at the scale of capital markets with the goal of developing a financing model which can alleviate the pressure leading to deforestation, restore land, and move commodity production to sustainable systems, as well as conserve forest and promote sustainable rural development. Public and private sector efforts will be analyzed and transition scenarios towards sustainable REDD+ implementation will be sketched out. The authors will conclude with a set of high-level policy recommendations in view of integrating the three Rio Conventions.

An investigation into the interactions between climate change initiatives in Ghana. Opoku, P., Weber, N. (*Dresden University of Technology, Germany; opoku_patrick@yahoo.com; nweber@forst.tu-dresden.de*).

The international community has developed policy instruments intended to conserve forest and mitigate climate change in developing countries. These measures include the programmes REDD+ (Reduced Emissions from Deforestation and Forest Degradation), the Voluntary Partnership Agreement, and the Non Legally Binding Instrument on all Types of Forest. Each of these initiatives has its own objective, and could interact with and have different impacts upon the national economy, environment, and stakeholders. The nature of these interactions and impacts is not yet known, however. The purpose of this research is therefore to assess the interactions and impacts of international forestry initiatives for climate protection in Ghana. The study is part of an ongoing research study under the Alexander von Humboldt climate protection fellowship program in Germany. Data collection will involve focus group discussions and in-depth stakeholder consultation as well as expert interviews in Ghana and Germany with support from the Institute of Forest Economics and Forest Management Planning, Technical University of Dresden, Germany. The findings and perceptions are to provide a basis from which to derive recommendations for improved implementation and coordination of international initiatives in Ghana in order to increase the effectiveness of climate protection measures.

Market conditions for forestry contractors in Slovakia. Palus, H., Kaputa, V. (*Technical University in Zvolen, Slovakia; kaputa@tuzvo.sk*).

The objective of this paper is to present the conditions of the forestry contractors market in Slovakia with emphasis on silviculture and harvesting operations. It analyses the relations between contractors and forest owners, contract negotiation conditions, contract terms, perception of transaction costs, occurrence of specific investments, and opportunistic behaviour in the context of a transaction cost economy. The main method for collecting information about the market was a standardized interview with selected contractors and forest owners. Three different forest owners and seven contractors were interviewed in areas relating to company characteristics, public policy measures, contracts, social and environmental influences, and anticipated future market development. Analyses of the interview results showed that contactors strove to offer as wide a range of services as possible and, at the same time, they tried to avoid specific investments unless they were guaranteed either by the time period of the contract or by the volume of contracted works in order to cover at least half of the specifically required investments. Conditions regarding the time flexibility of contracts, subcontracting activities, consideration of transaction costs, and the parties' negotiation positions are also discussed.

Wood flow analysis in the Slovak forest industry. Parobek, J., Palus, H. (*Technical University in Zvolen, Slovakia; parobek@tuzvo.sk; palus@tuzvo.sk*).

This paper deals with modeling wood use in the forest products industry and related industries under the principles of sustainability in Slovakia. Two different approaches were used for the analysis: wood balance and wood resources balance. The wood balance model covered the basic relationships between the resources and uses of wood and quantified consumption of wood. The wood resources balance model covered all possible applications of wood in various forms, including flows of wood material and wood residues. The wood resources balance method required collecting data through empirical research. Because the cascade use of wood was considered, the wood resources balance model calculated higher consumption of wood (12 million m^3) compared to the wood balance model (8.4 million m^3). Moreover, results indicated that the sawmilling industry consumed 43%, wood-based panels industry 15%, pulp and paper industry 26%, energy sector 10%, and households 6% of the total domestic wood consumption. The paper also presents a comprehensive model of wood flows between the resources and utilization of wood in different sectors.

Preferences of new forest owners in Serbia. Petrovic, N. (*University of Belgrade, Serbia; nenad.petrovic@sfb.bg.ac.rs*), Pezdevšek Malovrh, Š. (*University of Ljubljana, Slovenia; Spela.PezdevsekMalovrh@bf.uni-lj.si*), Avdibegović, M. (*University of Sarajevo, Bosnia and Herzegovina; mavdibegovic@gmail.com*).

The total share of private forests in Serbia is 47%, a percentage that has not changed drastically since the process of nationalization in 1946. Nationalization was carried out by depriving large forest owners of their forests and establishing the maximum amount of land that a private individual could own. This policy reduced the total area of private forest, but left the significant presence of a large number of private forest owners with relatively equal amounts of forest land in their control under the legal maximum. After the restitution of forests to churches and religious communities beginning in 2006 and the 2010 law on general restitution, the stage was set for restitution to large forest owners. The heirs of once large forest owners are new stakeholders with potentially different preferences for the use of forests in comparison with the current small forest owners, whose wood is usually

used to meet personal needs. The heirs are new actors in the forest policy arena, representing different values, interests, and power from those of the usual participants. For the purpose of adjusting the existing forest policy to take into account the new forest owners, this study will investigate their preferences for forest management and the use of their recently inherited forest property.

Mill capacity to utilize logging residues for bioenergy production in the southern United States. Pokharel, R., Grala, R. (*Mississippi State University, USA; rpokharel@cfr.msstate.edu; rgrala@cfr.msstate.edu*).

The potential for utilizing logging residues as a feedstock for bioenergy production by mills in the southern United States depends on their willingness to utilize, pay for, and haul logging residues. A mail survey was sent in 2012 to southern mills to study their capacity to utilize woody residues and determine their willingness to utilize, pay for, and haul additional logging residues for bioenergy production. About 11% of mills were willing to utilize additional logging residues. Mills were willing to pay an average gate price of US$16/ton and haul logging residues over 65 miles. Willingness to utilize additional logging residues had a significant impact on gate price and hauling distance. The price mills were willing to pay at gate was significantly different between mills with differing capacities, but there was no effect of capacity on hauling distance. High transportation cost was the most important limitation for additional utilization of logging residues, followed by limited storage space, processing capacity, and available equipment. Results indicated that there was a potential and willingness of southern mills to utilize logging residues, suggesting that there is an an opportunity to increase woody residue utilization. These findings will be helpful in developing policies related to wood-based energy production.

Linking science and policy: changing policy-maker behavior through action research in forest value chains. Purnomo, H. (*Center for International Forestry Research (CIFOR) & Bogor Agricultural University, Indonesia; h.purnomo@cgiar.org*), Shantiko, B., Achdiawan, R. (*Center for International Forestry Research (CIFOR), Indonesia; b.shantiko@cgiar.org; r.achdiawan@cgiar.org*).

Imbalanced distribution of added value among participants in forest value chains weakens the sustainability of forests and forest products. Regional trade policies such as the China-Association of Southeast Asia Nations (ASEAN) free trade agreement can worsen the situation of small-scale producers in Indonesia, if such policies are not strengthened. Much research on forest and forest products has been done, but can the behavior of policy-makers change? This paper describes the link between science and policy throughout the research process underlying the development of a long-term furniture strategy plan to improve value added for smallholders. It explores the problem in Jepara district, Central Java, which is the center of furniture manufacturing in Indonesia with an export value of US$120 million annually. The authors have been doing action research, outcome mapping, and innovation diffusion to boundary partners at different levels in an effort to make science count in policy formulation and implementation. The authors found that clear links between science and policy exist due to the action research. They recommend using action research and outcome mapping at various levels to facilitate better governance in support of better management of forests and the forest industry and fair distribution of their value added.

Formulating a proposal for a strategy to prevent and control fires in protected areas by means of governance criteria. Rivera Coria, W. (*National Federation of Municipal Governments of Bolivia (FAM), Bolivia; riveraw@gmail.com*).

Bolivia has adopted an integrated management system that allows settlers in protected areas to be present at and take part in management processes concerning these areas. According to the Servicio Nacional de Áreas Protegidas (SNAP; National Service for Protected Areas), fires constitute a powerful threat to the resources located in these areas and poor production practices related to the use of fire in agricultural work were found to be the main underlying cause. Fire is regarded as an efficient low-cost resource that is used to prepare land for cultivation and pasture purposes. The present paper outlines a strategy to prevent and control fires in protected areas. The author addresses systematic measures initiated to change production patterns and a new approach to the organization of production, certified production, and regulation of ownership in order to stabilize the borders of agricultural land with strictly protected areas. The work builds on a methodological formulation regarding the governance of natural resources (GTZ, 2004) based on the Institutional Analysis and Development Framework (Ostrom, 1999). It was expanded upon in cooperation with SNAP, validated in a participatory way by the directors of 19 protected areas in the country and key actors, and published as a working document in 2008.

Analysis of the non-state forest sector in Slovakia. Sarvasova, Z., Moravcik, M., Schwarz, M., Lásková, J. (*National Forest Centre, Slovakia; moravcik@nlcsk.org*; *schwarz@nlcsk.org; laskova@nlcsk.org*), Šálka, J. (*Technical University Zvolen, Slovakia; salka@tuzvo.sk*), Dobšinská, Z., Hricova, Z.

Non-state forestry in Slovakia has been investigated under the research project APVV -0057-11 VYNALES (Research of the impact of non-state forest ownership on forest related policies). One of the partial objectives of the project was to analyze the non-state forestry sector using the SWOT methodology approach, which identifies four basic attributes of non-state forestry: strengths (S), weaknesses (W), opportunities (O), and threats (T) related to private forestry. The paper analyses the internal and external environment and the strategic scenarios resulting from synthesis of the SWOT analysis outcomes. SO strategy is aimed at private-sector opportunities linked to the existence of associations, leaders, and active members who are involved in fund-raising opportunities. ST strategy uses strengths to avoid external threats and presents a more appropriate strategy due to the predominance of external threats and internal strengths. WO strategy describes opportunities to minimize or overcome internal weaknesses to exploit opportunities that result from the fragmentation of ownership and association members. WT strategy is based on obtaining the relative unity of the associations to avoid the negative financial impact of the external environment.

Comparison between Western and Eastern historical views of sustainability (Nachhaltigkeit) principles of forest use. Shiba, M. (*University of the Ryukyus, Japan; mshiba@agr.u-ryukyu.ac.jp*), Jemali, N., Binti Ahmad Zawawi, A. (*Kagoshima University, Japan; idiana0303@yahoo.com; azitazawawi@gmail.com*), Chinen, Y. (*University of the Ryukyus, Japan; akamayaa@yahoo.co.jp*).

The Yambaru region located in the northern part of Okinawa's main island belongs to a subtropical marine climate zone. This climate has created the bountiful forests of Yambaru, and those forests have nurtured important habitats for a large number of internationally recognized, widespread native species. Efforts are being made to designate the Yambaru forest as a national park because of its inscription on the UNESCO World Heritage list. On another front, during the age of the Ryukyu Kingdom (1609–1879), the Yambaru forest was respectfully managed under the Somayama (Royal Forest) system established by Sai On (1682–1761), who was one of the three chancellors of the Ryukyu Court. At Somayama the community people acquired all wood for building, heating, and production of utensils necessary for village life. After removing timber, they reforested areas, thereby protecting the forest through application of traditional practical knowledge. At the same time, the concept of sustainability was being expressed by Hans Carl von Carlowitz (1645–1714), director of the mines in Saxony, who wrote Sylvicultura Oeconomica in 1713. The authors discuss sustainable forestry based on community-level activity from the perspectives of Western and Eastern historical views of sustainability (Nachhaltigkeit).

Forest, climate mitigation and choice of policy means: How well suited are various bioenergy policies for combating climate change? Sjølie, H. (*Norwegian University of Life Sciences, Norway; hanne.sjolie@nmbu.no*), Latta, G. (*Oregon State University, USA; greg.latta@oregonstate.edu*), Solberg, B. (*Norwegian University of Life Sciences, Norway; birger.solberg@umb.no*).

Most industrialized countries have implemented policies to foster the use of bioenergy with the objective of mitigating climate change. With forests as the primary biomass source in many of these countries, the increased demand could trigger more harvesting which, depending on forest characteristics, could be incompatible with reductions of short-term atmospheric CO_2 levels. However, forest-based energy can also come from byproduct sources with very different CO_2 impacts. Furthermore, clearing land increases its albedo and therefore has a cooling effect on the climate. Thus, there are several factors which pull in different directions, complicating the overall climate impact of increased use of forest-based energy. By evaluating the greenhouse gas fluxes and albedo effects associated with an array of potential schemes, the authors attempt to provide insight into the following question: How well suited are various bioenergy policies to combat climate change? A partial equilibrium model of the Norwegian forest sector is used to simulate forest management and growth, harvest, wood processing, consumption, trade, greenhouse gas fluxes, and albedo effects over the next century. The results provide insight for policy-makers designing bioenergy policies in forest-rich countries with important albedo effects.

Response in forest policy as a result of reduced risk of stream salinity associated with timber harvesting in a changing climate. Stoneman, G., Kinal, J. (*Department of Parks and Wildlife, Australia; geoff.stoneman@dpaw.wa.gov.au; joe.kinal@dpaw.wa.gov.au*).

Precautionary salinity management practices have operated for more than 20 years in the lower rainfall areas of the jarrah and karri forests, guided by earlier hydrological research. These practices aimed to retain a minimum vegetation density in space and time, during timber harvesting and subsequent regeneration, to minimise the potential rise in groundwater levels and stream salinity. Substantial changes in silvicultural practices mean that the disturbance is now less intense than examined in previous hydrological studies. Declining annual rainfall has resulted in declining groundwater levels and stream salinity; groundwater levels that were near the surface in the 1970s and 1980s are now deeper than 5 m in much of the forest. Annual rainfall and groundwater levels are projected to decline further. As a part of the development of the Forest Management Plan 2014–2023, forest policy was reviewed and revised such that phased harvesting in second-order catchments in lower rainfall areas of much of the jarrah and karri forests is no longer necessary because the salinity risk has declined significantly and will remain low for the foreseeable future. Ongoing monitoring of groundwater level is to continue so that management can be responsive in the event of a return to a wetter climate.

Sustainability of slash pine forest stands in the southern United States under climate change. Susaeta Larrain, A. (*University of Florida, USA; asusaeta@ufl.edu*).

This paper analyzes the impacts of different levels of forest productivity scenarios due to changes in global temperatures and precipitation patterns in the context of climate change, on the economics of slash pine (*Pinus elliotti* var. *elliotti*) in the lower Coastal Plain in the southern United States. The ecophysiological model 3PG (Landsberg and Waring, 1997) was combined with the growth and yield model (Pienaar *et al*., 1996) to account for changes in total commercial volume, carbon stock, and proportion of forest products generated by the forest stand. A generalized economic model was used to determine the impacts of climate change on the land expectation values and carbon sequestration on hectare basis, and optimal harvesting decision. This economic model allows for estimating the impacts of both current and future changes in forest productivity on the current optimal harvesting decision. This work will also explore the effects of changes in tree planting density and site productivity index on the net economic rents for landowners, carbon sequestration, and optimal harvest age in light of changing climatic conditions.

Industry perspectives on wood as a structural green building material. Wade, A., Sinha, A., Knowles, C. (*Oregon State University, USA; wadeal@onid.orst.edu; arijit.sinha@oregonstate.edu; chris.knowles@oregonstate.edu*).

Green building is becoming an increasingly popular trend around the world, creating positive growth in green building materials markets. The purpose of this research is to understand the role of wood as a green building material in the structural system of new buildings. The study also aims to identify areas in which information is lacking with respect to reducing the environmental burden of structural building materials and to identify gaps in access to or availability of green building materials. Semi-structured group interviews composed of industry professionals representing all stages of the design and build process (i.e., architects, engineers, contractors) and experiences in different scales and functionalities of buildings will be used to gather information for this study. Interviews will be conducted in different regions of Oregon (USA) where the most growth is occurring, including the Portland metropolitan region, Corvallis, Eugene, and Bend. Results will focus on the role of green building rating systems in material selection, resources used by industry professionals to research green building materials, and understanding constraints and biases against using wood for structural systems of green buildings.

The value of adaptation to climate change for European forestry. Yousefpour, R. (*Max Planck Institute for Meteorology, Germany; rasoul.yousefpour@mpimet.mpg.de*).

Adapting to climate change implies revisiting of forest management decisions in different European case studies. However, the questions in most of the cases are (1) to make the most-adaptive decisions, (2) to find the best timing for switching from business-as-usual to the adaptive decision, and (3) to update information about forest and climate conditions over time and revisit adaptive decisions again if necessary. Adaptive decisions could be implemented now or postponed to benefit from the productivity of mature forests vulnerable to climate change impacts over a long time horizon. However, this is highly dependent on the age of the stands. Instead of supporting highly productive sites, it is more crucial to identify and support low productivity sites, which support ecosystems that are sensitive to climate change, with adaptation measures. Otherwise loss in productivity is expected to be 28–152%, as compared with a loss of 0.4–2.8% of expected productivity in more productive sites. However, in comparison with the worst (non-adaptive) decision, the largest possible gain (with an adaptive decision made with perfect information about climate change and impacts) could be up to 122% (23–122%) of land expectation value. Adaptation to climate change is not a one-time action and may be revisited at many decision points in response to new information about climate change and monitored impacts.